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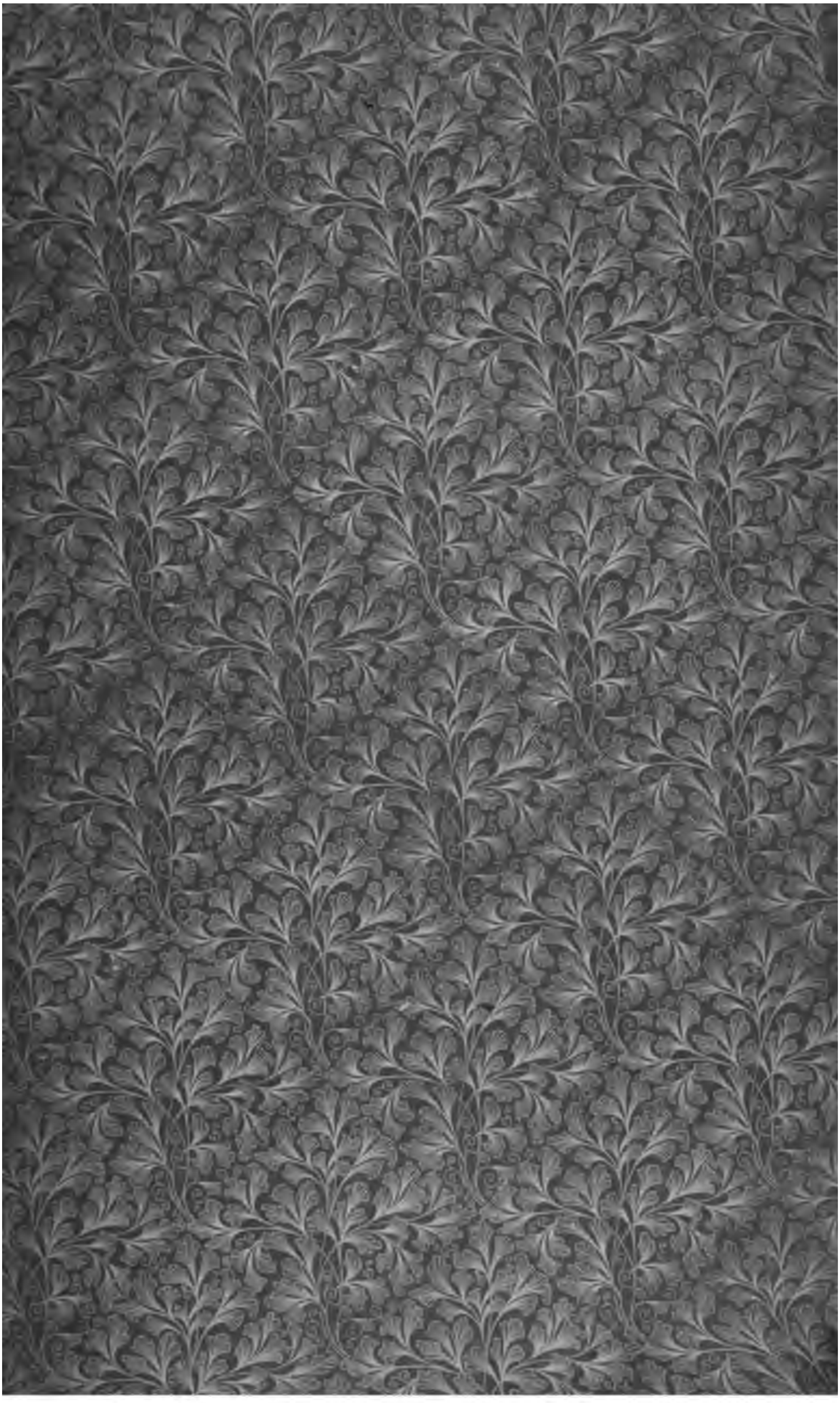

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A MANUAL

ON

DISEASES OF THE EYE AND EAR

FOR THE

USE OF STUDENTS AND PRACTITIONERS

BY

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TO

DR. RICHARD H. DERBY,

SURGEON TO THE NEW YORK EYE AND EAR INFIRMARY,

AND

DR. HENRY D. NOYES,

PROFESSOR OF OPHTHALMOLOGY AND OTOLOGY, BELLEVUE HOSPITAL MEDICAL
COLLEGE; SURGEON TO THE NEW YORK EYE AND EAR INFIRMARY, ETC.,

THIS VOLUME IS RESPECTFULLY

Dedicated

IN GRATEFUL RECOGNITION OF THEIR VALUABLE

TEACHINGS.

PREFACE.

THE importance of the study of the Diseases of the Eye and Ear by every student of medicine is best shown by the fact that many of the medical colleges, especially those in England, have made the study of these diseases obligatory for graduation.

The want of a short practical manual of the diseases of the eye and ear in the English language has long been felt by the medical student. I have, therefore, at the request of many members of my private classes, given in this little book my lectures upon these subjects, somewhat enlarged.

It has been my aim to make this book as practical and brief as the great importance of the subject would permit. I hope that I have not omitted anything that might be of interest. I have made it a point to be as thorough as possible in the description, treatment and differential diagnosis of those diseases which we are most apt to meet with in general practice. I hope their recognition will be facilitated by the introductory remarks, and by the admirable illustrations that I have been able to obtain from Sichel's Atlas; whilst the study of the affections of the choroid, the retina, and the optic nerve, which is only possible with the ophthalmoscope, is facilitated by plates which have been taken from the accurate and famous works of Liebreich and Wells.

I have thought that it would be of additional value to give, together with the description of the diseases of the eye, a short account of the diseases of the ear, which deserve more attention from the general practitioner than has been accorded to them. Cases of diseases of the ear at their beginning, are more apt to fall into the hands of the general practitioner than into the care of the specialist. The latter is likely to see them when changes which must result in permanent impairment of hearing have already taken place.

The accompanying plates, which are copies from those of Politzer, will be found of great service in the study of the diseased conditions of the drum-head. I have not thought it necessary to occupy any space with illustrations of instruments which can be found in the catalogues of any instrument maker.

The number of authors that I have had occasion to consult has been so great, that I shall give their names below.

The use of the more extensive text-books on the subject cannot be replaced by this little work, which is intended for the elementary study of the diseases of the eye and ear only. If it should serve such a purpose satisfactorily and meet the wants of the medical profession at large, I shall consider myself amply repaid for my trouble.

NEW YORK, 123 East 25th Street,
December, 1880.

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PART I.

THE EYE.

INTRODUCTION.

On examining a patient suffering with a disease of the eye, we have to decide first, whether we have to deal with an external trouble, affecting the appendages of the eye or the eyeball itself, or whether the impairment of vision constitutes the principal complaint, which would indicate a lesion of the deeper tissues of the eye, or of the dioptric apparatus. An affection of the appendages of the eye seldom implicates the sight of the patient directly to any extent, but some of these troubles, for instance, disease of the lids or of the conjunctiva, may have been brought on by a faulty refraction.

If the patient complains about an apparent deformity of the eye or the lids, it will be easier to make a diagnosis, than in other cases where defective sight or pain is complained of, when the complaint of the patient requires a more careful investigation.

The examination should begin with a scrutiny of the patient's face and eyes, in order to see whether any lesions of the skin of the face or the lids exist. Most of the diseases of the lids will be recognized at a glance, also the diseased conditions of the orbit, as the most prominent symptom of a disease of the latter is apt to show itself by a great prominence of the eyeball — exophthalmus. The condition of the skin may also serve as a guide in deeper inflammations of the eye. A markedly syphilitic eruption of the face, which we sometimes meet with, called "Corona veneris," will make us think at once of specific iritis or even of syphilitic choroidal affections.

Eczematous patches, not only of the lids, but on the nose and ears, very often accompany phlyctenular troubles of the conjunctiva or cornea. A swollen or thickened condition of the lids, semi-ptosical, generally points to some trouble of the conjunctiva.

An examination of the eye itself will now reveal to us whether the position of the eyeball is correct, or whether there is a deviation of one eye from the line of vision, as we see it in strabismus or muscular paralysis. In observing now the movements of the eyeball, any defects of the muscular apparatus will become at once apparent. The next step is to see whether the secretion of the eye is normal; there may be an abundance of tears in the eye, epiphora, or small crusts in the inner corner of the eye, conjunctivitis, or the eyelashes may be glued together and call for an investigation in this direction. If only one eye shows these symptoms, and if by pressing in the region of the tear sac the discharge is increased, it is probably due to an obstruction or inflammation of the tear passage. If the discharge is only found on the lashes, and on removal of the crusts the edge of the lid is seen to be implicated, the trouble is a Blepharadenitis. If the discharge is mucous or muco-purulent, its source is probably the conjunctiva. In order to verify this an inspection of the conjunctiva becomes necessary.

By directing the patient to look upwards and then drawing down the lower lid, by traction on the integument of it, the conjunctiva of the lower half of the eye will be fully exposed. The examination of the upper half is not so easy and may require some skill. In order to evert the upper lid, the thumb of the left hand should be pressed firmly against the brow, to neutralize the action of the occipito-frontalis muscle; the patient must now be directed not to wrinkle his forehead and to look downward with both eyes. The ciliæ of the upper lid are then seized with the fingers of the right hand and gently drawn downwards and forwards, lifting the lid from the eyeball. The left thumb holding the brow must now be moved downwards, pushing the brow and the integument of the upper lid into the depression created by the downward look of the patient. If this is done firmly and gently, the upper lid can be everted without the slightest trouble, by lifting it simply upwards and a little outwards. The patient still looking at the floor, and the thumb of the left hand still exerting a gentle pressure downwards, the conjunctival surface of the upper lid, and especially the upper fold of transmission becomes fully exposed, and any diseased conditions of the conjunctiva can be recognized at once. For the evertion of the upper lid the use of a pencil or a small piece of wood or a match may be of service, by pressing it into the depression of the upper lid caused by the downward look of the patient and everting the lid with the other hand, but after a little practice of the above described method, it will seldom be necessary to use a pencil or piece of wood. The use of it will sometimes cause a little pain, and may frighten the patient, making an examination more difficult; nor will it be possible to expose the upper fold of transmission as fully as in the method given above. If there is much irritation of the eye, and especially if there are severe contractions of the orbicularis muscle, it may be very difficult to evert the lids, but with a little perseverance, avoiding all unnecessary force, we are almost sure to succeed. In very severe cases of Blepharospasm it may be necessary, however, to etherize the patient before the lids can be everted. The use of a lid retractor only serves to expose the cornea, but is of no service for the inspection of the conjunctiva.

If the discharge is only watery, copious, and accompanied by dread of light, and is of sudden occurrence and recent origin, it is probably due to a foreign body in the eye. An examination of the conjunctiva would reveal its existence readily. Foreign bodies produce more pain and irritation if they are imbedded in the cornea. In blue eyes their discovery is easy, in dark eyes the oblique illumination of the cornea should be resorted to. This is accomplished by concentrating the light (both artificial and daylight may be used) on the cornea by means of a strong convex lens; moving this cone of light in different directions, the whole surface of the cornea can now be thoroughly examined. The image of a window as seen on the cornea can also be used for the discovery of a foreign body or an abrasion on the cornea. The lachrymation and photophobia may be due also to corneal or iritic affections. If this is the case an examination of the cornea by direct illumination will reveal any lack of transparency and by the oblique illumination we discover any irregularity or loss of tissue of the cornea.

In iritic affections we have especially the condition of the pupil to help us in our diagnosis; we must see whether this is immovable or irregular, or if the pupillary space is normal. A change of the normal black appearance of the pupil might be due to old age, when the reflex of the lens gives the pupil a grayish-blue appearance. Other changes of it may be due to an opaque mass filling up the pupillary space; this is the result of an inflammatory process of the iris, or in very rare cases due to a remaining pupillary membrane; the latter is a congenital condition. Opaque masses posterior to the plane of the iris are due to changes of the capsule of the lens if immediately behind the iris; of the lens itself if some distance behind the iris. In very rare cases vitreous opacities may change the black appearance of the pupil; they are far behind the pupillary space and are movable. If the reflex of the pupil is yellow, it may be due to a purulent infiltration of the vitreous body or to a tumor of the retina, glioma, or to a tumor of the choroid or to the remains of purulent choroiditis, as we see it sometimes after cerebro-spinal meningitis. This condition as well as a glioma are seen especially in children. Such eyes are partly or totally blind. Changes in the stroma of the iris, if they are not accompanied by inflammatory symptoms, may be due to atrophy, if the iris appears very thin and transparent, or due to an irido-choroiditis, if there is principally a change in the color of the iris.

A change in the vascularity of the conjunctiva of the eyeball indicates conjunctival trouble, if it is superficial, bright red, suffused over a large portion of the conjunctiva, and if it becomes more intense towards the fold of transmission ; if it is, however, principally or almost exclusively around the corneal margin, deep, of a delicate rosy or even bluish tint, and if the vessels are very small and radiating from the cornea, more intense at the corneal margin than at the periphery, it will indicate disease of the iris or cornea or ciliary body. This is the so-called ciliary injection.

If pain is the principal symptom, it may be caused by inflammatory conditions of the sclera, the cornea, the iris, the choroid, or the ciliary body ; if the pain is very severe at times, accompanied by the sensation of flashes of light and sparks, and followed by impaired vision and cessation of pain, glaucoma may be looked for. Pain without inflammatory symptoms may be of a neuralgic character, especially of the supra-orbital nerve, which is tender on pressure ; this pain is independent of the use of the eye, but if it is brought on by the use of the eye, it is probably asthenopic and is due to errors of refraction, such as hypermetropia and astigmatism, at times also to high degrees of myopia.

If defective sight or entire loss of vision is complained of, we have to ascertain whether both eyes or only one is at fault. Is the trouble in one eye only, we should see first of all, whether it is due to some opacity of the refractive media of the eye. Maculæ corneæ are easily seen by direct or oblique illumination as whitish gray opaque spots. Seen with the ophthalmoscope, these, as well as the opacities of the lens and vitreous body, will appear as black masses in a red field, because they do not allow the rays of light, returning from the fundus of the eye, to pass through the spot, whilst the rest of the background of the eye appears as a red disc. If these black masses are anterior to the iris, they must be seated in the cornea ; if they are on a plane posterior to the iris and stationary, they are located in the lens; if they are far behind the iris and floating whenever the eye is moved, they are in the vitreous. Are the media clear, the defective sight may be due to an error of refraction, such eyes will be benefited by the proper glasses, but if glasses do not improve the vision, and especially if the trouble is of recent origin, diseases of the lens, the retina, the optic nerve, or of the choroid, suggest themselves. Before the discovery of the ophthalmoscope these affections were all classed under the head of amblyopia, if the vision was only impaired, and amaurosis if the sight was entirely lost. As there is hardly any change in the appearance of the pupil, which appears black as in the normal condition, these affections were also called black cataracts. Thanks to the help of the ophthalmoscope these diseases are no longer a mystery to us. (See Use of Ophthalmoscope.)

CHAPTER I.

THE ORBIT.

THE orbit is a bony cavity 45 mm. deep, pyramidal in shape, the apex corresponding with the optic foramen, the base with the free edge of the orbit. It is here 32 mm. high and 38 mm. wide and the base is directed forwards and outwards. It is composed of seven different bones. They are covered with periosteum, which is a continuation of the dura mater on the one hand and of the periosteum of the bones of the face on the other. The periosteum is firmly attached to the bones at the entrance of the different foramina and at the orbital margin only, and it splits at the orbital side of the optic foramen, where it sends off a portion for the formation of the outer sheath of the optic nerve, which afterwards becomes blended with the sclera, and at the margin of the orbit where it forms the tarso-orbital fascia, which after running over and around the cartilaginous tissue of the lids, forms the fibrous tunic of the eyeball. There are as many as nine foramina leading to or from the orbit.

They are: the optic foramen, for the passage of the optic nerve and the ophthalmic artery; it is a short canal, 8 mm. long and 6 mm. wide, lined by the dura mater. Next in importance comes the sphenoidal fissure for the passage of the ophthalmic vein, the 3d,4th and 6th, and branches of the ophthalmic division of the 5th nerve; the spheno-maxillary fissure, which transmits the superior maxillary nerve, the infra-orbital artery and branches from Meckel's ganglion, the supra-orbital foramen and the infra-orbital canal for the corresponding nerves and blood-vessels. The anterior and posterior ethmoidal and the malar foramen and the lachrymal canal for the lachrymal duct. The roof of the orbit separates it from the cranial cavity and the frontal sinus; the floor from the antrum of Highmore and the inner wall from the nasal cavity; the outer wall is strengthened by the zygomatic process. The orbit is filled with nerves, blood-vessels, and muscles, which are imbedded in adipose tissue, which by the lids, and especially by the tarso-orbital fascia, is kept in place.

The diseases of the orbit may affect either the bones and the periosteum or the nerves and blood-vessels, or the orbital tissue. An inflammatory action of these tissues must necessarily lead to an increase of the contents of the orbit, and as the tarso-orbital fascia is strong and resisting, the effect will be shown principally by the eyeball; this will be pushed forward, so that it becomes more prominent: *Exophthalmus, Proptosis.*—If the exophthalmus is very marked, it may lead to impairment of vision by stretching of the optic nerve or by ulceration of the cornea; the lids are not able to cover and protect the eye, and the exposure may lead to a breaking down of the cornea.

Exophthalmus can be differentiated from prominent eyes by the fact that an exophthalmic eye projects farther than a straight line drawn from the upper to the lower orbital margin. Exophthalmus is, however, not only met with in orbital troubles; its causes are manifold; it may be due to:

1. *Myopia.*—The eye becomes elongated in the antero-posterior direction in highly myopic eyes; it cannot press the orbital tissue together, and must, therefore, project considerably. Myopia occurs generally in both eyes; it develops very slowly, and the sight of the patient can be greatly improved by concave glasses.

2. *Hydrocephalus* will, in children, depress the roof of the orbit and push the eyeball forwards, giving it a downward look; it affects both eyes. The size of the head, as well as other symptoms, will help us in our diagnosis.

3. *Dislocation of the Eyeball.*—When the lower lid is torn, the eyeball seems to lie on the cheek, apparently dislocated. This can easily be remedied by sewing the lower lid together; but if the eyeball has been torn out of its socket, it is difficult to replace; it will remain more or less prominent, and the stretching of the nerve or the rupture of it, will seriously affect the vision of this eye. Such an eye, if the orbital tissues are not entirely torn away, must be replaced as soon as possible, and kept in its place by means of a very tight compress bandage. It affects one eye only, as a rule, and the history of the case will help us in making a diagnosis.

4. *Paralysis of the Recti Muscles.*—By the healthy action of the recti muscles, the eyeball is held in the orbit. If these muscles are paralyzed, the oblique muscles are apt to draw the eye forward. The immobility of the eyeball and the suddenness of the attack render the diagnosis easy. The vision is seldom impaired.

5. *Inflammation of the Capsule of Tenon*, as it occurs in *pan-*

ophthalmitis (Fig. xxiv), will make the eye very prominent. It is one of the severest diseases of the eye; the sight is entirely destroyed and the whole interior of the eye becomes filled with pus. It is an acute disease and will run its course in a few weeks.

6. *Staphyloma of the cornea or sclera* (Fig. xvi) will make the eyeball protrude between the lids. In this condition the opacity of the cornea, the change of the shape of the eyeball and the loss of vision help us in our diagnosis.

7. *Hydrophthalmus.*—This is a bulging of the anterior half of the eyeball; it is congenital, or due to severe diseases of the eye during early infancy. The whole of the eye has a bluish color, due to thinness of the sclera, allowing the dark choroid to shine through. The anterior chamber is very deep, the iris stretched and atrophied, and the vision is very poor. It affects generally one eye only.

8. *Tumors.*—They may be tumors of the orbit, pushing the eyeball forward, or they may affect the eyeball *itself*, causing an increase of its volume, or they may come from the neighboring cavities (nose or antrum of Highmore).

9. *Exophthalmus* may also be due to disease of the *bone* and *periostitis of the orbit*. In these cases the eyeball is not only pushed forwards, but also to the side opposite to the seat of the trouble, thus causing diplopia.

10. *Orbital cellulitis* will, by an increase of the contents of the orbit, by hyperæmia and inflammatory products, push the eyeball forward in a straight direction; any pressure of such a protruding eye backward must naturally be painful. An intensely swollen condition of the lids and conjunctiva accompany this disease.

11. *Disease of the Blood-vessels of the Orbit.*—It may be an *aneurism* of the vessels, or it may be due to a general increase of the volume of the vessels, as in

12. *Grave's Disease, or Exophthalmic Goitre.*—This variety of exophthalmus affects both eyes; the upper lid is retracted, and this gives the eye a very peculiar staring expression. The diagnosis is easy. The presence of heart symptoms, or enlargement of the thyroid gland, are of diagnostic importance.

Diseases of the Bones and Periosteum of the Orbit.—The affections of the bones of the orbit are intimately associated, and generally begin with a diseased condition of the periosteum. There are, however, diseased conditions of the bone, where an increase of bone takes place without hardly any signs of irritation; these bony tumors of the orbital walls develop very slowly, and as they grow, they push the eyeball in a direction opposite to their location, and forwards. This is peculiar to affections of the orbital walls and of tumors of the orbit; they disturb the eye from its normal relations to the fellow eye; so that its visual axis lies on a different plane from that of the other eye: this produces *diplopia.*

Of course the patient sees double only, having both eyes open. It is therefore called *binocular diplopia* (monocular diplopia is complained of when, on account of opacities of the cornea or lens, the patient sees two or more images of an object with one eye). As these bony tumors grow larger, they can be felt to be very hard and resistant. They are nodular in shape or flat.

Injuries of the orbit affecting its walls are of great importance, especially when the roof of the orbit has been injured. This is apt to lead to cerebral troubles (abscess of the brain). Of frequent occurrence in fractures of the base of the skull is the implication of the optic foramen, which may lead to great changes in the function of the optic nerve. Fracture of the skull or any part of the orbit will be accompanied by ecchymosis, appearing first under the conjunctiva of the eyeball, later on the conjunctiva of the lids, and lastly, if at all, on the outer surface of the lid. If the periosteum becomes affected (*periostitis*), it may develop as an acute process, but it is generally a chronic affection, lasting for many months, even years. It is very painful if it affects the edge or apex of the orbit, where the periosteum is closely attached to the bone, not so much so if any other portion is affected. The pain may precede any other visible sign for many weeks; it is generally a dull pain over the brow of the affected eye, which later becomes sharp and severe and deeper seated. The pain becomes severer on pressure of the orbital margin, which is an important diagnostic sign. If the orbital margin is the seat of the trouble, a hard immovable thickening can be felt early; if a deeper portion is affected, exophthalmus and diplopia will develop before any marked swelling takes place. Eventually an affection of the surrounding tissues and the lid takes place; the integument breaks down and allows a discharge of a small quantity of pus; on introducing a probe, a piece of dead or denuded bone is felt. The fistulous opening discharges for some time, till the diseased bone has been discharged, broken up in small fragments or in one large piece—but it is not often that large pieces of bone can be removed through such an opening. The vision of the eye remains generally good and the muscles of the eyeball are seldom interfered with, so that the eye can be moved in all directions, but motion is generally somewhat limited towards the affected side.

Differential Diagnosis.—From (1) benign and cystic tumors it can be differentiated by the absence of pain and the inflammatory signs of these affections, and (2) malignant disease of the orbit is accompanied by an early affection of the muscles of the eyeball, consequently there is impaired mobility and there is early infiltration and discoloration of the surrounding skin. (3) Cellulitis of the orbit is a more acute process; the direction of the exophthalmus is straightforward, not to one side; diplopia not so much marked; the vision is early affected and pressure of the eyeball backwards is very painful. (4) Exophthalmic goitre affects both eyes, the exophthalmus is straightforward, the eye staring.

Causes.—Periostitis of the orbit is generally due to some injury; it develops more or less rapidly, but it may come on many years after a blow or a fall. It is due also to syphilis and is sometimes met with in young children of strumous condition, or is due to exposure, favored by a low condition of the system. Its duration varies and depends upon the location and size of the affected parts. The prognosis is not always good. The abscess resulting from the periostitis is most apt to point on the surface of the lids; a fistulous opening remains, which by contraction on healing may lead to ectropium. The denuded bone may become covered again by healthy granulations and heal, or it may break down and may even lead to cerebral complications and death.

Treatment.—Local applications, such as ice or lead-water applications, are not of much use; the constitutional causes ought to be treated especially; tonics, and of these the syrup of iodide of iron, is of great value. The general hygienic condition of the patient should receive attention, and exposure to colds and wet ought to be avoided. As early as possible an incision ought to be made, to relieve the tension of the periosteum and to prevent the implication of the underlying bone. After an opening has been established by rupture or operation, keep it as widely dilated as possible, by the use of a sponge or laminaria tent, if necessary, but in most cases a little plug of oakum saturated in balsam of Peru (Dr. James R. Wood), will be sufficient to accomplish it; this will also stimulate the process of repair; it should be removed as often as twice a day until the sinus heals from the bottom. Complications of the optic nerve may be brought about by direct extension of the process or by traction in marked cases of exophthalmus. In these cases the cornea may slough from exposure. In order to avoid this the lids may be closed by means of adhesive plaster; in severer cases the sewing together of the lids may be called for; but this is, as a rule, only necessary in cases of malignant disease of the orbit.

Diseases of the Frontal Sinus.—The bones of the orbital wall may become more or less affected in diseases of the frontal sinus. The frontal sinus may become diseased by retained mucus, or by an affection of the bones; it may become filled with pus, abscess of the frontal sinus; it will result at first in a bony hard swelling, which is generally most prominent in the region of the brow, near the inner canthus; later, the periosteum and also the surrounding orbital tissue begins to swell, and a more or less marked exophthalmus will be the result. The eyeball becomes very prominent and is very much depressed, so that it lies apparently on the cheek. The difference in the level of the two eyes may be more than one inch, this produces of course marked diplopia, and the cornea is constantly in danger on account of its exposed condition. The integument is generally not affected in the first stages of the disease, but later suppuration may take place.

The disease is generally a very chronic affection, and may last many years, if not attended to. It is generally the result of an injury, but it may come on many years after the trauma occurred. By the great thickening of the margin of the orbit, which may extend up to the forehead, and by its slow development it differs from marginal periostitis and abscess of the lachrymal sac.

It can only be relieved by surgical interference. The most prominent portion of the swelling must be opened, and a drainage tube, or better, a strong silk thread, must be introduced after re-establishing the communication between the sinus and the nose, which is done by perforating the floor of the sinus by means of a trochar, which is introduced from the incision made into the swelling. A finger should be introduced into the nose, when this is done, in order to avoid the wounding of the nose. The drainage tube is to be worn as long as the discharge continues, and the cavity of the sinus may be injected and cleaned through this tube, by means of a mild solution of carbolic acid (Bull).

Cellulitis, or *phlegmanous inflammation of the orbital tissue*, is of rare occurrence. It is due more frequently to injuries of the orbit itself, or to the surrounding tissues, or it appears as a metastatic abscess in the puerperal state, pyæmia, etc. It may follow operations on the eye, for squint for instance, or it may be due to the entrance of foreign bodies into the orbit, or by an extension of an erysipelatous process to the deeper portions of the orbit.

Orbital cellulitis brings about great tissue-changes. Hyperæmia of the vessels, exudation and proliferation of cells will soon produce such an increase of the orbital contents, that great pain and great prominence of the eyeball become early symptoms. The return circulation of the eyeball being interfered with, the lids become œdematous, red, tense, and painful to the touch; the effusion into the subconjunctival tissue takes place to such an extent that the chemosis is apt to cover the entire cornea, and even protrude between the lids; hyperæmia of the deeper vessels of the eyeball (retina) may develop, and the extension of the inflammation to the nerve-sheath may lead to great changes in the optic nerve itself. The inflammatory exudation will soon glue muscles and orbital tissue together. The exophthalmus, which is characterized by a direct protrusion of the eyeball, is associated with greatly impaired mobility, and pressure directly backward becomes very painful. Exposure is not the greatest danger to the eye in this condition; the chief danger lies in the chemosis interfering with the nutrition of the cornea, and in extension of the inflammatory process directly to the optic nerve, or to the eyeball, causing a general inflammation of all ocular tissues (panophthalmitis). The pain is very severe and located especially deep in the orbit. High febrile symptoms with severe chills accompany this process. After the lapse of only a few weeks, the abscess will begin to point, and will open generally into the conjunctival sac, sometimes, however, near the margin of the orbit through the integument.

This condition differs from (1) periostitis by the forward direction of the exophthalmus, the absence of diplopia, and an early implication of the muscles of the eye; from (2) vascular tumors of the orbit by its acute history, great local heat, and the absence of pulsation; from (3) panophthalmitis by the condition of the deeper parts of the eyeball, and the fact that there is more or less vision left; from (4) malignant tumors by the rapidity and violence of the attacks, the febrile symptoms, and the absence of a special cachexia; from (5) purulent ophthalmia, by the absence of the secretion characteristic of this disease.

Treatment.—Energetic antiphlogistic measures are called for: ice applications to the eye and brow; leeches to the temples, four to eight in number; the use of a mild cathartic like Rochelle salts, ʒ ij, or ℥ ss, once or twice a day and energetic doses of quinine, say five grains in powder or in wafers, three or four times a day.

Incisions must be made as soon as the abscess has formed or is pointing, by means of a small scalpel; keep the wound discharging. Interference with the orbital tissue ought to be avoided as much as possible. Even if in these cases the incision is made before the formation of pus, it will do good by relieving the engorgement of the vessels, thus relieving the pain. The pain is so great that liberal doses of morphia, a quarter or a third of a grain, may be given as often as the occasion requires. If the chemosis of the conjunctiva is very marked, and the swelling of the lids great, so that there is danger of the destruction of the cornea, a canthoplasty should be made, which may act like a charm and relieve the pain very much.

As soon as an opening has been established, linen pledgets must be kept in the wound for several days, and local application of warm water or flaxseed poultices must be applied, to hasten the breaking down and the discharge of the inflammatory products. Not infrequently the periosteum suffers from the tension of the inflammatory process, and even necrosis of the orbital bones may follow.

Diseases of the blood-vessels of the orbit may affect the larger arteries or veins, and are often in such cases due to injuries which result in *aneurismal tumors;* they may attain considerable size and produce great exophthalmus. The pulsation of the tumor and the bruit, which may be very annoying to the patient, will help us in making our diagnosis. Hemorrhages are likewise due to injuries; they produce only limited exophthalmus, which will disappear as soon as the blood-clot is absorbed, which may be hastened by cold and, later, by hot applications. Such hemorrhages seldom require surgical interference, but in orbital aneurisms or simple vascular tumors of the orbit, the operation of ligating the internal carotid may become necessary, if digital compression of the artery fails.

In Grave's or *Basedow's disease*, or *exophthalmic goitre*, the dilation of the blood-vessels is due to a morbid state of the sympathetic nervous system, and is frequently caused by reflex irritation from the genital organs. It is a disease of puberty and affects especially females, but is also found at an advanced age, and men are likewise affected by it. It is associated with a marked nervous condition of the patients—they are easily excited, flush in the face, and are very bashful; they complain often of palpitation of the heart. The heart-beat is generally increased, varying from 90 to 130 or more a minute; the heart itself may not be affected or show simply slight hypertrophy, seldom dilatation. An enlargement of the thyroid gland is generally seen in these cases, but is not one of the lesions constantly found.

The exophthalmus presents peculiarities by which it is easily diagnosticated from other cases; it affects both eyes, but not always in the same degree, and the greatest prominence will sometimes change from one eye to the other. It is especially characterized by the staring expression, which is often the principal cause of the patient seeking advice, and is due to a retraction and impaired mobility of the upper lid, leaving a portion of sclera over the upper portion of the cornea exposed, which in the normal condition is always covered by the upper lid. This is quite marked, if the patient is looking directly forward, and is much increased when looking downwards, because the upper lid does not follow the eyeball. It is not often that the exophthalmus becomes so prominent as to lead to corneal complications. The treatment of this disease belongs properly to general medicine. The fluid extract of ergot, in doses of half a drachm to a drachm three times a day, combined, in cases of great irritation of the heart, with five-drop doses of the tincture of digitalis, has proved in my hands the most effective remedy.

℞. Tinct. digital. ʒi; fld. ext. ergot ℥i; tinct. gent. comp. ℥ii. S. A teaspoonful three times a day in water.

This ought to be combined with the use of the galvanic, or if this is not to be had, with the faradic current, applied every other day from five to ten minutes, placing the negative pole to the cervical region of the neck, and the positive pole alternately over the closed eyelids, the thyroid gland, and over the cardiac region. The hygienic treatment, proper attention to the genital organs and tonics must not be neglected.

Tumors of the Orbit; Cystic Tumors.—They may be simply cystic, containing more or less clear serous fluid (hydatid), or they may be of a dermoid nature, containing hairs, resembling lashes and cheesy matter. They may attain considerable size, developing slowly in the course of many months or even years; they may cause both exophthalmus and diplopia, but they do not interfere with the action of the muscles, and are not accompanied with any inflammatory symptoms. The cyst wall consists of dense fibrous tissue, and takes its origin in most cases from the periosteum of the orbit, to which it remains attached. They take their origin usually from a point of the periosteum where it splits and divides into different expansions; they are therefore attached to the margin of the orbit, or to the apex of the orbit, in the region of the optic foramen. The use of an exploring needle should be resorted to before an operation is decided upon. After an incision of the integument, the cyst wall ought to be exposed by careful dissection, and the whole, or as much of it as possible, ought to be removed, and if starting from the edge of the orbit, the wound should be sewed up; if the cyst starts from the apex of the orbit, a sinus will be found extending into the orbit. This should be kept open by means of a plug of oakum, saturated in balsam of Peru, till it heals up from the bottom. If this does not succeed a solution of nitrate of silver or tincture of iodine should be carefully applied to the cyst wall, by means of pledgets of cotton attached to a probe. Attempts at removal of the sinus from the orbit will often cause orbital cellulitis and other serious disturbances, which may lead to the destruction of the eye.

Malignant tumors of the orbit may take their origin in the orbit itself, and are frequently the result of old traumas, if affecting young patients; or they may encroach upon the orbit from neighboring tissues or cavities. They sometimes occasion attacks of sharp shooting pains and lead to an early implication of the muscles and integument. Their growth is more or less rapid, and their removal is absolutely necessary and should be attended to as early as possible, in order to save the eyeball. There is always great danger of a return after their extirpation. If the eyeball is also affected, the removal of the entire contents of the orbit becomes necessary.

Extirpation of the contents of the orbit, *evacuatio orbitæ*, is only called for in malignant growths, affecting the orbital contents and the surrounding tissues. If the lids in such cases are not affected, they must be saved if possible. The eyeball may also be saved in a few cases.

It is of great importance to determine, before operating, whether the growth started in the orbit, affected the bones of the orbit, or whether it attacked the orbit only after it had developed in a neighboring cavity. In such a case an operation will be useless, unless the growth can be removed from its starting-point at the same time. If the bones of the orbit are implicated, the prognosis of the case is not near as good as if only the contents of the orbit are affected. If there is any sight left in the eye and its mobility not impaired, the eyeball should be saved, if possible. In those cases in which we have an intra-ocular tumor to deal with, this alone should be removed (Enucleation, see Sympathetic Ophthalmia). If there are, however, any doubts about the participation of the orbital tissue, this should be likewise removed. 1. An intimate connection of the growth with the orbital bones must be suspected, if the tumor cannot be moved with our hand; 2, if the eyeball and the orbital tissues alone are affected, the growth can be moved by pressure but not by the muscular efforts of the patient; 3, if the eyeball alone is the seat of the trouble, the mobility of it is but little impaired. If it is possible to save the eyelids, the outer canthus should be slit and the lids reflected, any diseased portion of its conjunctival lining should be carefully removed and the growth should now be taken out, if possible, in one piece. The soft parts of the orbit should be very carefully cleared out, and the whole of the orbital cavity carefully treated with the actual cautery. If the roof or the walls of the orbit are very thin, for instance in children, and it is feared that the actual cautery might burn through the bone and affect the brain, the Vienna paste must be resorted to. This is made of one part of chloride of zinc and three parts of flour. This is to be mixed with a sufficient quantity of laudanum to make a thin paste of it, which should be smeared freely over the orbital walls.

Vascular or *erectile tumors* of the orbit are of comparatively rare occurrence; they form in the cellular tissue of the orbit and increase slowly, causing more or less exophthalmus, but they do not impair the patient's health or vision. The exophthalmus has a peculiar pulsation, which ceases if the eye is gently pressed backwards; it may even disappear on pressure, to resume its former size soon after the pressure is removed; it will also partly disappear if pressure is made on the internal carotid, and become larger by straining and by muscular efforts of the patient or after crying; the pulsation is not very strong and is hardly felt by the patient.

The diagnosis of such tumors is at times very difficult; it may be caused by intra-cranial affections, interfering with the return circulation by pressure on the ophthalmic vein. This is of importance to know in regard to the treatment, and the presence of other cerebral symptoms should be carefully looked for in these cases.

Aneurismal tumors of the orbit are of very rare occurrence; the pulsation and the bruit of these tumors are very marked, and are felt generally by the patient very plainly; their history is often connected with traumatism, and compression of the carotid diminishes the size of the tumor promptly, more so than in the erectile tumors. Other non-vascular tumors are more readily recognized.

Treatment.—This consists especially in surgical interference; the most reliable of all is the ligation of the internal carotid artery.

Electrolysis has given good results in a few cases and may be tried, if ligation of the carotid is not possible; care should be taken to attack only small portions of the tumor at a time. Injections of iron or tannin or carbolic acid have been made into the tumor, but great care should be taken to avoid the larger vessels of the growth, if possible.

CHAPTER II.

THE LIDS.

THE lids, two in number, are of the greatest importance in the protection of the eyeball. They close the orbit, and their free margins form an opening, the palpebral fissure, which is of varying size in different individuals and makes the eye appear either large or small. The upper lid is larger than the lower; they form two angles, the outer one, sharp-pointed, is called the outer canthus; the inner one, less pointed, is called the inner canthus. The lids are attached to the orbits by means of the tarso-orbital fascia, and at the sides by means of ligamentous bands, the internal or tendo oculi, and the external canthal ligaments. The lids are composed of different layers. The inner lining membrane, the conjunctiva, is continuous with that of the eyeball; the integument with that of the face; but it is very thin and is free of fat. The subcutaneous tissue is next in order; it is composed of fibrous tissue forming very large interspaces; it is freely movable, this enables us to pick up the skin in large folds; extravasations into its meshes are of frequent occurrence. Underlying this tissue is the muscular layer, the orbicularis muscles. It is a flat muscle, and it acts as a sphincter; it is very powerful and by its contraction closes the palpebral fissure; it is divided into three portions, the outer *orbital portion* reaches as far as the brows, and forms, with that of the lower lid, a perfect sphincter; it is connected with the occipito frontalis and the corrugator supercilii. The second portion is that covering the lids, called the *palpebral portion;* it arises from the tendo oculi; it is not a perfect sphincter, but it forms curves which come together at the outer canthus; it is pale and thin. Another portion is known as *Horner's Muscles*, or Tensor Tarsi. It runs from the crista lachrymalis, around the canaliculi, and is distributed to the inner portion of the free border of the lids. It helps to regulate the flow of tears from the eye to the nose. The orbicularis is supplied by the seventh or facial nerve. Under the muscular tissue we find a prolongation of the orbital fascia; to this the elevator of the upper lid is attached; the levator palpebræ superioris takes its origin from the upper portion of the tendinous ring which surrounds the optic foramen, runs towards the edge of the orbit and spreading like a fan, it is inserted into the tarso-orbital fascia; by its action on the fascia, the upper lid is drawn upwards; it opens the eye, and is supplied by the third or motor-oculi nerve. The fascia itself runs along the cartilage of the lids, turns over the free edge, runs backwards under the cartilage almost up to the orbit, but is reflected before this is reached, and it helps to form then the tunica vaginalis of the eyeball. Between these two layers of fascia, we find a dense, hard, fibrous tissue, commonly called the cartilage of the lid, although it does not contain any cartilage cells; the upper one is larger than that of the lower lid; it is semi-lunar in shape, with its convexity upwards; that of the lower lid is almost elliptical in shape; they serve to give the lid its proper shape, and changes in these tissues are apt to be followed by great changes of the lid. On the lower surface, and especially in the tissue itself, are depressions for the meibomian glands; they can be easily seen on turning the lid, showing through the conjunctiva; they are acinous glands, secreting a fatty substance which prevents the lids from sticking together. The conjunctiva is the last and innermost layer; it is very thin, transparent, and is firmly attached to the lids. The free edge of the lid is perfectly straight and smooth, it is 2–3 mm. thick, its inner margin is rectangular, the outer rounded. Its outer border is protected by a growth of strong hair, the ciliæ. The bulbs of the ciliæ lie in a layer of gray adipose tissue, between the muscular layer of the lids and the cartilage. Changes in the direction of the lashes are due to inflammatory changes in this portion of the lid. Into each of these hair-bulbs we have a number of sebaceous glands opening.

We have on the free edge of the lids a number of sebaceous glands, the tarsal glands proper, and mucous follicles; these latter are not numerous.

The glands of the skin of the lid do not differ from those of other portions of the skin. The free edge of the lid shows, near its inner margin, a row of fine dot-like openings of the meibomian glands, and near the middle of it the cartilage may be seen shining through the integument like a white line.

The nerves of the lids are three in number; two are motor, the third and seventh nerves, the other is derived from the fifth nerve; it is the nerve of sensation. The blood-vessels of the lid are derived partly from the branches of the external carotid, and these enter at the outer canthus. They are branches of the internal and external maxillary and superficial temporal arteries.

The blood derived from branches of the internal carotid enters the lids at the nasal side; these are branches of the ophthalmic artery, the palpebral arteries. These run under the muscular tissue of the upper and lower lids, and, joining at the outer canthus, form an arterial circle. Branches of the supraorbital, frontal and lachrymal arteries go to the lids also. There is free anastomosis between these vessels, and by it the larger arterial circle of the lids, which runs along the edge of the orbit, is formed.

The veins are superficial, and lie between the integument and muscle; they run towards the free edge of the lid, and here, turning under the muscular tissue, they form larger branches, which are later taken up in the facial vein, but some of the blood reaches the ophthalmic vein, which begins near the inner canthus. The fact that the veins turn into the deeper portion of lid at the free edge explains the fact, that by pressing the lids together, as in crying, photophobia, and blepharospasm, the lids are apt to become swollen and œdematous.

INJURIES AND WOUNDS OF THE LIDS are of frequent occurrence on account of the exposed position of the lids; they are apt to be followed by extensive exudations into the very loose connective tissue layer of the lid. This may be caused by blood, serum or air.

1. *Ecchymosis of the lids* may be the result of a blow or any other injury (black eye). The color of the lid will be a bright red, changing into a darker hue, becoming in a couple of days blue, and lastly of a greenish-yellow color. In fracture of the base of the skull we may get an ecchymosis of the lids, following the injury in about two or three days; it is preceded by an ecchymosis of the conjunctiva of the eyeball. If the patient is seen shortly after an injury, extensive ecchymosis may be prevented by the application of two or three leeches to the temples, near the outer canthus, because it is here that the blood-vessels going to the lids are very superficial. Leeches must not be applied to the lids, because their bites will leave scars which last for a long time; they may cause a good deal of œdematous swelling and even erysipelatous inflammation of the lids. Ice compresses are also of great service; they must be made of thin cloth, cooled on ice, and are to be frequently renewed. Later, warm and stimulating applications, like the tincture of arnica, a tablespoonful to a tumblerful of warm water, used freely every two hours, are of good service. The discoloration is best disguised by painting the affected parts with oil-colors. Some of our artists make this a very lucrative specialty. Cooling lotions, such as the liquor plumbi subacetatis ʒ i, wine of opium ʒ ij, to a pint of water, or a solution of

muriate of ammonia, ʒ i, nitrate of potash, ʒ ij, to a pint of water, are very useful and grateful to the patient.

Serous infiltrations of the connective tissue, resulting in *œdema of the lids*, are frequently seen after operations or injuries of the lids, and are greatly favored by the peculiar arrangement of the veins at the free edge of the lids; the injury may be slight, like the bite of an insect, and yet it may cause great swelling of the lid. It is also frequently found to occur in abscesses or inflammation of the skin of the face, erysipelas; it may accompany inflammatory processes of the conjunctiva or deeper processes in the eyeball, or in the orbital tissue, which cause obstruction to the venous circulation. After cataract extractions, when the eye itself cannot be examined, œdema of the upper lid may be the first sign of an inflammatory attack of the iris. External pressure by means of a bandage, or, in severe cases, where the heavy lid causes great pressure on the cornea, a canthoplastic operation (see page 90) will give great relief, and the use of a cooling lotion of lead and opium may be necessary.

Œdema of the lid will occur idiopathically and suddenly in persons in low state of health; it occurs generally during the night, and may be accompanied by extensive infiltration of the subconjunctival tissue. It is not dangerous, but it may be alarming to the patient. It will disappear promptly under the use of a compress bandage, sometimes in half an hour; if left alone it may last some days.

Deep wounds of the lids or blows, especially if implicating the canaliculi, and operations on the tear-passage, may be followed by a forcible entrance of air into the areolar tissue of the lid and produce an *emphysema of the lids*. It presents a swelling which is apt to increase if the patient blows his nose, and which presents that peculiar crackling sensation to the touch, which air, distributed into loose tissue, produces.

The treatment of this condition is simple; the compress bandage has to be applied firmly, and care must be taken not to blow the nose and thus force more air into the tissues; this will soon relieve the trouble. No other application is necessary, except in wounds, where sewing together of the parts, and some surgical dressing, may be needed.

Wounds of the lids must be carefully brought together. Great pains must be taken with the free edge of the lids, which, if this is not done, will leave a defect; the action of the muscular fibres drawing the tissues apart, produces a coloboma; besides, thickening or turning-in of these edges will cause injury to the eyeball itself. In bringing the torn lid together, Prof. Noyes likes to have a tooth-like projection of one edge fit into a corresponding notch made for this purpose on the free edge of the other side of the wound. Healing of the wound is greatly favored by perfect rest of the lids, which is obtained by the use of the pressure bandage. This will also prevent the very annoying swelling following such wounds. A *coloboma* of the lid occurs also as a congenital defect, mostly accompanied by imperfect development of other tissues of the eye; it is to be operated upon in the same manner as a traumatic coloboma.

Burns of the lids are very dangerous, because extensive deformities are apt to follow after the healing of such wounds. It is, therefore, advisable to apply also in these cases, after the wound has been dressed with a small piece of linen saturated in carbolized oil, five drops of carbolic acid to one ounce of sweet oil, a firm-pressure bandage; this must be kept up for five or six days, removing the dressing morning and evening. In this way we may hope to preserve the natural shape of the lid. Extensive burns are, however, apt to be followed by ectropium.

Inflammation of the lid may be seated in the skin, erysipelas, the connective tissue, phlegmon, or the glandular tissues. Erysipelas of the lids deserves hardly any special description here. Care must be taken not to mistake it for simple œdema of the lid or for dacryocystitis. Its tendency to spread, the glossy tense appearance of the skin, the high fever, and the constitutional symptoms make the diagnosis easy. As a local application I would recommend the use of the collodium painted over the inflamed parts. This, if care is taken not to let it get into the eye, is a very good cooling application: by the powerful contractile action of it, it serves as a counter-pressure; the swelling becomes less and is prevented from spreading. It should be applied by means of a camel's-hair pencil every three or four hours. Large doses of the tincture of iron, fifteen drops with one grain of quinine, should be given every two hours.

A phlegmanous inflammation of the lids is always accompanied with extensive swelling of the surrounding tissue; the eye is closed till the painful affection results in the breaking down of the tissues and in the formation of an abscess. This should be opened promptly by a horizontal incision, which will leave hardly any scar. Warm applications of the German chamomile tea are very grateful to the patient on account of the anodyne effect, and should be continued for a few days, until the wound has healed completely.

An inflammation of the glandular tissue may take place in the meibomian glands, the result will be a *chalazion* or in the sebaceous glands of a hair-follicle, then the result will be a hordeolum or in the tarsal glands resulting in blepharadenitis.

A *chalazion* is caused by a closure of the duct of a meibomian gland; the retained secretion will irritate the gland, and this will be followed by more or less marked inflammatory symptoms, chalazion acutum, or chronicum, and lastly by the formation of a small tumor (Fig. iii). The process is generally a slow one; the dense fibrous tissue in which the gland is imbedded will not admit of a rapid enlargement; eventually the cartilage will become thin and yield; the tumor will begin to be distinctly seen on the cutaneous surface of the lid; a growing inwards is prevented by the eyeball. The tumor is seldom larger than a split pea, but will, especially if it affects the less-resisting lower lid, become of the size of a hazel nut. It is always some distance from the free edge of the lid, and on turning the lid, its bluish wall can be seen to shine through the conjunctiva. Its contents are creamy, partly composed of pus in an acute case, but the older forms contain a thick sebaceous material. A chalazion may grow slowly for months and then remain stationary; at times it will diminish through the contraction and partial absorption of its contents, or it may break through the conjunctiva and discharge slowly into the conjunctival sac. Such an opening is often surrounded by large pedicellated masses of granulations. The treatment of a chalazion, of which we may have quite a number on one lid, is to make, after everting the lid, a crucial incision into the sac through the conjunctiva, and if possible remove not only the contents of the sac by gentle pressure, but also a part of the sac itself, or instead of this remove a portion of the projecting points of the crucial incision by means of scissors, in order to prevent a closing up of the sac. Mild astringent lotions, such as: ℞. Alum. gr. v; tinct. opii simp. gtts. x; aq. camphor. ℥ i, instilled into the eye, two drops at a time, three times a day, are of great service. Never cut through the integument of the lid, even if the tumor is pointing here very strongly. Remember, that in order to get to the tumor from this side, you have to cut through the orbicularis and the fibrous layer of the lid; but at the inner side you have merely to cut through the conjunctiva.

From small sebaceous cysts of the surface of the lid, it is easily differentiated by the fact, that it can be always seen through the conjunctiva on everting the lid, and that it cannot be moved without moving the cartilage of the lid at the same time. From a hordeolum, by the fact, that it is generally not so near to the free edge of the lid, that it is very slow in its development, and that the overlying skin is not inflamed.

A hordeolum or stye (Fig. ii). is generally caused by an inflammation of tarsal glands surrounding and opening into a hair-follicle; it is generally accompanied by the formation of pus and an extension of the inflammatory process to the surrounding tissue, and a large amount of œdema of the lids, with chemosis of the conjunctiva, especially if the process is located near the external canthus. The swelling may result in complete closure of the lids. Very soon the small abscess will point, and on opening it with a needle or knife, a small amount of pus will escape. The trouble is not dangerous, but may become very annoying to the patient by the great stretching of the tissues, and it is also quite painful. In the beginning, the removal of the central eyelash may cut short the inflammation; a cooling lotion of subacetate of lead, very much diluted, or if the tissues are very tense, a warm poultice of bread and milk, or the free use of sweet oil, will give great relief. After the abscess has been opened an infusion of the German chamomile flower can be used, and on going to bed, to prevent the gluing of the lids together, the application of a little cold cream is very useful. Sulphide of calcium may be used internally.

Inflammation of the small tarsal glands, *blepharadenitis* (Fig. iv). The glands of Zeiss in the free edge of the lid, are greatly exposed to the irritating effects of cold and dust, the overflowing of sharp tears, especially in phlyctenular conjunctivitis, the irritating effects of foul air and great straining which causes hyperæmia of the free edge of the lids, as we have it occur in errors of refraction, especially in hypermetropia, and astigmatism. When the cause is not removed all these conditions may lead to an inflammation of the glands, blepharadenitis but an inflammation of the glands will generally affect also the skin and surrounding tissues, ophthalmia tarsi or blepharitis ciliaris. According to the extent of the inflammatory action, we get different varieties of the disease. The common blepharadenitis results in an altered secretion of the glands. In the normal state the secretion is very thin and evaporates completely. In the morbid state the secretion is thicker, contains mucus and epithelial cells and leaves, on evaporation, a brown mass which glues the eyelashes together. On removing these crusts, we find the skin reddened and easily bleeding. The patient complains about an itching sensation, and keeps rubbing the lids, which in turn irritates them again.

Later, large crusts are seen on the reddened eyelids and on the lashes; the latter become loosened and are easily removed with the crusts; they may eventually be entirely lost, *madarosis*, which constitutes a great deformity. If this trouble continues for some time, and especially if the crusts are not removed and the lids thoroughly cleansed, ulceration of the skin is apt to take place, and on removal of the crusts, small ulcerations of the surface can be seen. These may heal and contract and the lids become red and hard. If they are not attended to, the process will result in spreading of the ulceration and eventually in destruction of the free edge of the lid, which will become pointed. The inflammation extends to the integument, and a broad red margin of ulceration, or red cicatricial tissue will disfigure the patient, and will cause permanent deformity; the lids cannot be closed entirely; the tears will run over the cheek and cause irritation of the lid. The conjunctiva suffers likewise, becomes thickened, irregular, and velvety.

This may be the result of many months' or years' action; it has therefore been called *Blepharadenitis antiqua* or *Lippitudo* (see Fig. iv.) Usually the process extends to the entire edge of both lids, but if due to localized trouble of the conjunctiva, it may affect only the glands surrounding one or more lashes, *Blepharadenitis solitaris.*

The process may be a very chronic one, lasting for years, but, not resulting in the breaking down of tissue, it may lead to a proliferation of cells, resulting in great hypertrophy of the edge of the lid, *Blepharadenitis hypertrophica* or *Tylosis.* This is generally found to occur in long continued affections of the conjunctiva, especially after conjunctivitis phlyctenularis. Another much milder form attacks people with very delicate skin, especially those with red hair. The slightest irritation of wind, dust, or the bad air of crowded, badly ventilated rooms, such as lecture-rooms and theatres, or dark, badly ventilated sleeping apartments, may cause in such persons a very troublesome, reddened condition of the lid, which is accompanied by small furfuraceous scales, which cover the inflamed edge of the lid, and are also found adherent to the lashes, *Blepharadenitis squamosa.* This form will not lead to ulcerations and deformity, but it will keep up a very annoying irritation of the conjunctiva. Another variety is apt to be accompanied with numerous small hordeoli, *Blepharadenitis hordeolosa.* It attacks persons in debilitated conditions.

Treatment.—The main point in the treatment of this troublesome disease is the removal of the cause. Ametropic eyes should have the proper glasses selected for them, even atropia, to paralyze all accommodative efforts and temporary use of blue glasses may speedily remove the most alarming symptoms. Great cleanliness, removal of the crusts, moderate habits, and plenty of fresh good air, for the sleeping apartment especially, are of great help in the treatment of Blepharadenitis. The use of liquor plumbi subacetatis, six drops to a small cup of water, applied five or six times a day, for five or ten minutes, to the irritated edges of the lids, by means of a soft piece of linen, will not only allay the irritation and relieve the congestion in a very short time, but it will also prevent to a great extent the formation of crusts. As a specific remedy, we must look upon the red oxide of mercury ointment. It should be a very mild preparation, and may be used with or without the liq. plumbi subacetatis. ℞. Hydr. oxyd. rub. gr. j; liq. plumbi subacetatis, gtts. iij; vaseline. ʒi. Mix carefully. S.—To be applied to the edge of the lid on going to bed. Before this salve is applied, the crusts must be carefully removed, the parts well dried, and the ointment rubbed well into the lashes; the patient closing the eyes gently while this is done. Only a very small quantity of the salve should be used, a piece of the size of the head of a pin is sufficient; it must not get into the eye. It may be difficult and painful to remove the crusts, and in such cases an emollient application for this purpose is of great help; applying sweet oil freely to the crusts and leaving it in contact with the lid and washing it off later with warm water, or the use of a poultice of bread and warm milk, applied for a few minutes, will soften the matted ciliæ and crusts. Generally the use of warm water continued for a few minutes will be sufficient for the purpose. By the forcible removal of the crusts without these precautions, the eyelashes are apt to be torn out, and may never grow again. The ointment must be prepared with great care, the fine crystals of the red oxide of hydrargyrum must be reduced to very fine powder, or they will irritate the lids too much, and cause more redness and even slight swelling. The yellow oxide of hydrargyrum may also be used. Only a small quantity of the salve should be given to the patient, as it is apt to spoil in a few weeks; it will change from a red to a gray color. The use of the vaseline instead of simple cerate prevents it, however, from getting rancid, which was a great inconvenience before vaseline was used. The treatment of some of the other varieties of blepharadenitis must differ somewhat. The ulcerative variety requires the use of nitrate of silver; if the ulcerations are superficial, a solution of five grains of silver to an ounce of water, should be applied by means of a brush to the well cleaned lids once a day. Care must be taken not to apply it to the skin of the lid, as it would cause discoloration. It may be washed off after a few moments with a solution of salt. Deeper ulcerations must be touched with the finely pointed stick of nitrate of silver, and this must not be washed off. The red oxide of mercury salve is to be used at nights, or instead of it the following salve: ℞. Hydr. precip. albi, zinci oxyd. albi, āā gr. iij; vaseline, ʒi. M. f. ungt. Apply on going to bed. In order to facilitate the treatment of this formidable trouble, it may be advisable to cut off the ciliæ with scissors, close up to the skin: by doing this, there is less danger of the loss of the lashes. The old chronic variety, with great redness of the edges of the lids, is benefited by a stimulating salve, composed of

℞. Hydr. oxyd. rubr. gr. v; ol. cadini. gtts. x; vaseline, ʒij; M. f. ungt. S.—To be applied at night before going to bed, or this formula: ℞. ol. cadini. gtts. x; zinci oxyd. albi. gtts. xv; Ungt. simp. ʒij. M. f. ungt. To be used at night. During the day liq. plumbi subacetatis, diluted, should be used.

The squamous variety is especially apt to annoy ladies with very delicate skin; it is a very obstinate disease. In the milder form the treatment with the liquor plumbi subacetatis and the mild red oxide of mercury ointment, may be useful; this ought to be followed by the use of a mild astringent, like alum or borax. As this variety is very apt to be complicated with conjunctivitis, a little of this astringent may be allowed to get into the eye. ℞. Sodæ biboratis, gr. x; aq. rosae, ℥ij; aq. laurocer. ℥ss; mucilag. cydoniorum, ℥ss. M. (Derby). S.—To be applied to the eye twice a day; or, ℞. Alum. gr. x; aq. camph. ℥ij, may be used. If nearly all the furfuraceous crusts, as well as the redness of the lid has disappeared, the following preparation will serve to keep the lids, and especially its glandular tissue, in healthy condition, and thus prevent relapses, which are of such frequent occurrence.

℞. Spir. vini gallici. ℥ss; spir. lav. simpl. ℥ss; spir. rosmar. simp. ℥ij. D.—Bathe the eye with this every evening. Care must be taken not to let the spirits get into the eye, as it will smart considerably. In prescribing the spirits, do not forget to order the simple and not the ordinary compound spirits of lavender, which contains so much coloring matter that it would discolor the eyelids; and also the simple spirits of rosemary, because the officinal compound spirits of rosemary contains spirits of hartshorn, which would irritate the eye.

The variety complicated with many hordeoli and œdema of the lid requires, besides the local treatment, which in the beginning should be the free use of the diluted liq. plumbi subacetatis, to be followed by mild astringents and constitutional treatment; quinine and iron are also very useful. ℞. Syr. ferri, quiniæ and strychniæ phosphatis, ℥ ij. D. S.—A teaspoonful in water before each meal. Plenty of out-door exercise and good nutritious food are of great importance. Sulph. of calcium, ⅛ grain *ter in die* is very useful.

Eczema of the lids does not differ in any respect from other eczematous affections. It is especially a disease of childhood, and is frequently the result of a lowered condition of health: it may also be caused by local irritation. It accompanies therefore frequently scrofulous affections, is one of the sequelæ of measles and scarlatina, and is also found with diseases of the eyes, that are accompanied by lachrymation. It will begin as a little vesicle, and spread more or less rapidly until the lids are covered with crusts.

Frequently other eczematous attacks of the mouth, head, or ears are found at the same time. On account of the itching of the sores, children are apt to scratch and tear them open, the blood becomes mixed with the secretion, and large crusts will cover the lids. If the trouble has existed for any length of time, great changes of the skin will take place; the skin becomes hard and red, and fissures and cracks may be seen in it. Contractions of the skin will often result in slight degrees of ectropium, by which the puncta lachrymalia are drawn from the eye, so that the tears cannot enter the canaliculi, and epiphora will be the result, which in turn irritates the already abnormal skin anew. Another slight but very tedious variety of this disease is found to affect persons with very delicate skin, causing a scaly deposit like dandruff to cover the lids. The treatment of this affection requires the removal of the causes, for instance, slitting of the canaliculi in epiphora or the treatment of phlyctenular conjunctivitis, and frequently calls for a regulation of the diet of the patient. ℞. Fl. ext. rhei, ʒ j; sodæ bicarb. ʒ ij; aq. menth. pip. ℥ iv; essentiæ zingiberis, ʒ ss. Dose.—From a teaspoonful to a tablespoonful three times a day. This will be found to be of the greatest benefit, and should be followed by tonics. After a thorough removal of the crusts, washing the parts with castile soap and warm water, and drying them carefully, without rubbing too hard or otherwise irritating the parts; the local treatment should consist of an application of an ointment of ℞. Hydr. oxyd. rubri, gr. v; morph. sulph. gr. j; ungt. simp. ʒ ij. M. f. ungt. S.—Apply mornings and evenings after washing the parts. This ointment will allay the troublesome itching and give the skin a chance to heal, which will generally take place in a few days. The hard, dry skin resulting from a long continued attack, as well as the squamous variety of the disease, are greatly benefited by using—℞. Olei cadini et glycerini, āā ʒ ij. S.—Apply freely at night before going to bed.

Phthiriasis, or lice of the eyelashes, may often lead to a condition resembling blepharadenitis or eczema of the lid. These little insects will cause a great deal of itching and irritation of the edge of the lid; this will be aggravated by scratching. The lashes will be seen to be covered with crusts, but, on closer inspection, also with the eggs of the lice; sometimes two or three may be seen on each cilia, and the insect itself can be seen, especially through a magnifying lens, very distinctly. The application of a mild solution of carbolic acid, or better, the use of the gray mercurial salve, applied at nights, and removed in the morning by means of soap and warm water, will speedily destroy the insects.

Abnormal formations found on the lids are (1) *warts*. They may develop on any part of the lid, and even on the free edge of it, where they may become the source of great irritation to the eye; they are generally small, bloodless, pedicellated; sometimes they are large, broad, and quite vascular. Old people are more troubled with them than young persons. The smaller are easily removed by cutting them off with scissors and will hardly bleed; the scar should be touched delicately with a stick of nitrate of silver, which is better than nitric acid, as this will spread after it has been applied and may do harm to the eye. The larger ones may be burnt off, but the best plan is, after cutting them off, and waiting until it ceases to bleed, to apply a caustic. Warty growths of old people are sometimes the beginning of epithelioma.

(2.) Atheromatous growths and cysts are frequently found in children; they are generally superficial and often found in great number; they are covered with very thin skin, and are filled with a thick cheesy material, composed of fat and epithelial cells. They are found on all parts of the lids. Simple incision and pressing out of the contents is all the treatment that is required. Smaller ones, of the size of a flax seed, are found, especially near the free edge of the lid; they are obstructed sebaceous glands, and are called (3.) *Milium.*—With a pin the sac can easily be ruptured, when the matter will escape.

(4.) *Hyaline vesicles.*—Small vesicles, filled with a clear fluid, are sometimes found on the edge of the lid, projecting over the inner margin; they are apt to rub on the cornea and cause irritation of the eye. They are perfectly harmless; the vesicle will burst and disappear. This can be hastened by rupturing the vesicle with a needle.

(5.) *Dermoid cysts* on or near the lids are not very rare; they are sometimes congenital, or are connected with some old injury to the eye. They grow slowly, and are not inflamed except when irritated; then they become painful and develop more rapidly. On opening the cysts, which ought to be done by careful dissection, the greater portion of the cysts can be exposed and easily removed from its attachment; this is frequently the upper border of the orbit. The contents are sometimes a brownish fluid or a cheesy, whitish material. The number of hairs found in them vary considerably, one, or more than twenty may be found in these tumors. The wound heals generally rapidly, and no fear of its return need be entertained.

Ulcerations are often found affecting the lids; they may be either syphilitic, lupoid, or cancerous.

Syphilitic ulcerations of the lids are amongst the secondary and tertiary manifestations of syphilis; they are generally found in adults, and begin as a small red spot on the margin of the lid; this breaks down and the ulcer spreads rapidly, often destroying a large portion of the lid. The ulcer is deep, covered with a white soft fibrinous matter; the edges become everted and thickened, and are more or less rounded. There is generally nocturnal pain connected with the disease, its progress is generally slow and the preaural or the postaural glands are generally enlarged. Other syphilitic manifestations, and the history of the case will help us in our diagnosis. Much rarer are *chancres* of the lids; they are round indurated sores, followed by enlarged glands and secondary manifestations. Of the treatment of the primary sores, nothing need be said here; secondary ulcerations are, however, very tedious, and may last for years; one of the best remedies, especially if iodide of potash is not well borne by the patient, or is without effect, is the iodide of sodium. ℞. Sodii iodidi, ʒij; tinct. gent. comp., syr. sarsap. comp. āā ℥i. D.—One teaspoonful three times a day. The dose must be increased if necessary. Some cases do better under mercury, which should be applied in the form of inunctions or mercurial baths. As a local dressing use the following salve: ℞. Hydr. oxyd. rubr. gr. x; morph. sulph. gr. j; ungt. simpl. ʒiij. M. S.—Applied on a soft linen rag, held gently in place by strips of adhesive plaster.

Lupus of the eyelid is a much rarer affection: it is generally associated with lupus of other parts of the body, and affects young people. The sore is superficial, covered with sloughing tissue, and is irregular in outline, with soft tubercles at the periphery. The cyanide of mercury has proven to be one of the best remedies in my hands, combined with local use of the stick of nitrate of silver freely applied. ℞. Hydr. cyanati, gr. i; pot. iodid. ʒij; tr. card. comp, syr. simp. āā ℥ij. Dose.—From a half to a teaspoonful three times a day.

Epithelioma of the lids is of more frequent occurrence than lupus. It attacks old people, and may be very slow in the beginning, spreading more rapidly when once fairly developed.

A small wart may be seen a short distance from the margin of the lid; this may remain in a quiet state for many years, when on account of failing health of the patient, or from some irritating cause, the wart-like tumor begins to itch and cause pain and becomes moist on the surface. Soon it becomes a small ulcer which, as it breaks down, spreads into the surrounding tissue. We shall soon have a depressed ulcer in the centre; surrounding this is a hard indurated border, with great proliferation of cells of the affected tissue, causing a peculiar papular thickening. This, breaking down in turn, enlarges the ulcers and spreads the induration farther. The ulcer is shining and has many sago-like elevations on it. It will soon spread deeper, affect the bones of the orbit, and spread to the eyeball itself, destroying it slowly. This does not seem to cause, however, often sympathetic inflammation of the other eye. An early diagnosis is of the greatest importance, as the only remedy, the knife, should be applied as early as possible. The sooner the trouble is removed the less chance there is of a return of it. Epithelioma presents a deep ulcer with a thickened margin and an irregularity of surface; the border, implicating the surrounding tissue extensively, is hard and nodular; the discharge is not abundant in the beginning, but more so later on; there is seldom enlargement of the preaural gland and but little pain. If the discharge and pain are troublesome, the free use of iodoform, in fine powder, dusted freely over the affected parts, will give great relief. Butter of antimony may be sufficient in some cases to destroy the tumor, especially if applied during the earlier stages.

Herpes zoster will attack the eyelids, together with one side of the head, and frequently will be complicated with diseases of the conjunctiva and cornea. The eruption generally extends to the scalp; it begins as small eczematous vesicles, which break easily and leave a raw surface which becomes covered with small round crusts. It spreads along the course of a nerve, and is accompanied by severe attacks of pain. It never crosses the median line of the face. It is a disease that requires tonic treatment. The galvanic current should be used freely for ten minutes every day. Quinine and iron, or better, arsenic and quinine, should be used; five-drop doses of Fowler's solution three times a day after eating, and also three to five grains of quinine three times a day.

Changes in the Mobility of the Lids.—These are *ptosis*, *lagophthalmus* and *blepharospasm.*

Ptosis, an inability to raise the upper lid, is due either to lesions of the levator or the nerve supplying it, the motor-oculi nerve—true ptosis; or it is due to an increase in size and weight of the lid—false ptosis. If the paralysis is complete, the eye is perfectly closed, but on lifting the lid, the patient is able to use his eye as well as before.

Ptosis may be congenital, affecting either one or both eyes, and in these cases the superior rectus is apt to be also affected; but generally it is an acquired condition. If it is due to a lesion of the muscles, it is caused either by an injury of the muscle or of the orbital walls, or by an extension of a morbid process to the muscle, which loses its contractile power. If it is due to a paralysis of the nerve, it may accompany a central lesion, and is apt to be associated with paralysis of other muscles supplied by the third nerve, or by lesions of other nerves; the superior rectus being more intimately related to the levator, is apt to be affected at the same time. Of the central causes, cerebral tumors and hemorrhages and syphilis must be mentioned; of the peripheral, colds and the reflex irritations of injuries and lesions of the fifth nerve. The treatment of the disease must be directed mainly to the causes. The use of iodide of potash and quinine, and especially the use of the faradic current, must be resorted to promptly, for if the trouble exists for any length of time, the levator and the superior rectus will suffer from non-use. Should these remedies fail to cure in a reasonable time, or especially in congenital cases, an operation is necessary. For this purpose a fold of skin, semilunar in shape, and a piece of the underlying orbicularis muscle must be removed. Carry your incision along the margin of the upper lid, about four mm. from its edge, and another one connecting with it, and corresponding to the curvature of the cartilage of the lid. It is well to put the lid on the stretch by the use of the ectropium forceps, but it can be easily done without them. After the incision is made, remove the included portion of the skin by means of scissors; remove now also a small piece of the muscle, and after the bleeding has ceased, bring the parts together by four or five sutures of black silk. Clean the parts well, dress the wound with a piece of linen saturated with vaseline, and apply a firm pressure bandage over the eye, which may be left on for thirty-six or forty-eight hours after the operation; the stitches may now be removed. A condition resembling ptosis may be caused by long continued inflammation of the lid itself or of the conjunctiva. An inflammation of the lid, erysipelatous or scrofulous, may cause a considerable drooping of the lid. Granulated lids, or the other conjunctival troubles, cause a very slight degree of the trouble only; a semi-ptosical appearance of the lid is very characteristic of old granulated lids. If the case is very marked an operation may be necessary.

Paralysis of the sphincter of the lid may be due to old age, causing atrophy of the muscular fibres; the lower lid begins to droop; this will eventually develop into complete ectropium. A complete paralysis of the orbicularis muscle is due to lesions of the seventh nerve, and is one of the features of a facial hemiplegia. The eye cannot be closed by the action of the orbicularis and remains open, lagophthalmus paralyticus. If the eye is closed by pressing the lids together, they will remain closed and the eye can be readily opened again by the action of the levator muscle. In paralysis of the third nerve the patient cannot open his eye, in paralysis of the seventh, he cannot close it. Together with the inability to close it, there is a drooping of the lower lid which prevents the punctum lachrymalis coming into contact with the tears of the eye, causing epiphora, which in slight cases of facial hemiplegia may be the only sign of an affection of the orbicularis muscle. In rare cases the facial paralysis is limited to the orbicularis; the sensation of the parts is seldom disturbed. The contrast between the affected and healthy eye is very marked if the patient makes an effort to close the eye, the healthy muscle acting very forcibly, whilst the eye remains undisturbed on the paralyzed side. The cause of the condition may be central or peripheral; it is often due to exposure to cold winds, to riding in a car with a window open, or standing on a sail-boat, etc. Of the central causes, syphilis is perhaps one of the most frequent; if the hearing is likewise affected, the lesion must be looked for in or near that portion of the temporal bone where the two nerves are in close apposition. The treatment must include the use of electricity; the faradic current should be applied, the negative pole to the neck, the positive over the affected muscle, for ten or fifteen minutes every other day. Iodide of potash, with or without mercury as the case may demand, should be given freely. The great danger is the exposed condition of the cornea, which may result in severe ulcerations. To prevent this the eye may be closed during the day by small pieces of court or adhesive plaster; during the night the patient will have little trouble to keep the eye closed after he has learned to close it with his hand.

Spasms of the orbicularis muscle are to be looked upon as manifestations of reflex irritation. They are either clonic, of short but frequent attacks, *nictitation*, occurring especially in weak nervous persons, and in hysterical women suffering from leucorrhœa, or come on after excessive use of the eyes, or after slight conjunctival trouble; they may be very annoying to the patient and hard to cure; they require general treatment as well as local, electricity and the use of a tonic lotion. ℞. Spr. vini. gall. and spir. rosmarini, āā ℥ ij. To be used as a lotion for the eyelids three times a day. The other variety, tonic in its character, *blepharospasm* is of longer duration and a more serious affection. The cause of it, very obscure at times, is most frequently irritation of exposed nerve fibres of the cornea or iris by light. An ulcer of the cornea or an inflammation of the iris is accompanied by loss of epithelial cells, the light strikes the denuded terminal nerve fibres, and this will at once cause firm closure of the lids, to shut off the offending light. From long continued irritation the muscle will be so sensitive, that the slightest irritation will bring on an attack. Traction or irritation of a branch of the fifth nerve, for instance, painful scars implicating these branches, or a decaying tooth, is amongst the causes; but at times it will come on without apparent cause, the person being only excited at the time, crossing a narrow bridge, or a crowded street, thus exposing the patient to great danger. Again, a wound, but especially a foreign body scratching the cornea, will cause it.

Treatment.—This is at times difficult, especially if the cause cannot be readily removed. Atropia, acting as a local anæsthetic, does much good, or the fluid extract of conium, given in large doses of twenty to thirty drops, repeated every hour if necessary, may cure it; or submersing the patient's face entirely under cold water, or dropping ice-water on the inflamed cornea, will give temporary relief; resection of an old scar, the removal of a decayed tooth, or in some obscure cases the removal of a piece of the orbicularis muscle, with or without any integument of the lid, as it is described on page 34 for ptosis, may be necessary. Counter irritation has been recommended, but its value is doubtful.

Deformities of the lids.—These are due to imperfect development—*coloboma*, or *epicanthus*, or they are due to morbid changes of the lid—*entropium*, *ectropium*, *symblepharon* and *anchyloblepharon*, or to changes in the direction of the lashes, *trichiasis* and *distichiasis*.

Coloboma of the lids is a congenital imperfection of the lid, the centre of the lid presenting a deeply-notched appearance; it is mostly associated with other defects of the eye. It may be traumatic; it is caused by imperfect union after injuries of the lids. The edges of the coloboma have to be pared off and brought together by deep sutures.

Epicanthus is a congenital deformity, connected with a very broad nose and small palpebral fissures. The inner canthi are covered by a broad membranous expansion of the skin of the nose. As the child grows, the deformity is apt to become less, the eyes remaining, however, small. Should the deformity not improve, a broad elliptical piece should be removed from the centre of the broad bridge of the nose, which will make this part considerably narrower, and free the internal canthi.

Entropium is a condition in which the free edge of the lid turns inward upon itself, so that it cannot be seen, except by slight traction of the lid, when it will become again visible. The cause of this condition is either contraction of the inner lining membrane of the lids, the conjunctiva, or an abnormally relaxed integument. In the first case the edge of the lid is drawn inward by cicatricial changes of the conjunctiva, and especially by contraction of the cartilage, a condition we meet with in old cases of trachoma; in these cases it is of course always associated with turning in of the lashes. In the other condition it is generally due to a spasmodic action of the orbicularis, in acute inflammatory actions of the eye, with more or less œdema of the lids, or by a slight irritation of the conjunctiva of old persons with very loose skin. The use of a pressure bandage, improperly applied, is apt to cause it, especially in old people.

The treatment of entropium depends upon the causes; if it is of the spastic variety, due to inflammation of the eye, temporary means are called for, until the inflammation subsides. when the lid returns to its normal position. Several small strips of adhesive plaster applied at right angles to the edge of the lid, and fastened, after exerting gentle traction, to the skin, above or below as the case may be; or painting collodium vertically some distance from the edge will also draw the lid out and keep it out for some time, till the inflammation subsides. A canthoplasty is also of great benefit in these cases, especially if the trouble is due to conjunctivitis phlyctenularis or blennorrhœic troubles.

The senile variety may exist for a long time without much annoyance, especially if the edge is completely inverted, so that the lashes do not irritate the eye. If the patients are of very delicate health, or object to operative interference, a lotion of ʒj. of borax to a pint of lukewarm water, used morning and evening, for bathing the lids, is very agreeable to the patient. A simple operation is the removal of a piece of the loose skin of the lid, which will exert such a traction on the edge of the lid, so as to replace and keep it in its normal position; the piece ought to be an elliptical one taken from the lower lid, which in these cases is the one that is usually affected.

Another method (von Graefe) is to make a horizontal incision along the whole border of the lower lid, two to three mm. from its edge, then to make a Y-shape incision, the point downward, and the base to connect with the horizontal incision. The triangular piece is now excised, the edges loosened and sewed together in a vertical line, leaving the horizontal line to heal without sutures.

Entropium due to contractions of the lid caused by granulated lids, may be relieved by excising an elliptical piece of skin and muscular fibres, and grooving the cartilage in a horizontal direction and bringing the wounds together by deep stitches. Another method of great value is to turn the lid, and to expose the conjunctival surface; through the conjunctiva the upper edge of the cartilage is distinctly seen, divide the conjunctiva at this point by a deep incision, let the lid return to its natural position and take out an elliptical piece from the skin. Bringing the wound on the surface of the lid together will now suffice to keep the lid in place.

Ectropium (Fig. V.) is an eversion of the lid exposing the conjunctiva. It is caused by a contraction of the skin of the lid or neighboring tissue, or to a relaxation of the orbicularis muscle, on account of which the lid is allowed to droop; later by gradual thickening of the exposed conjunctiva, the free edge becomes very heavy and rolls over completely; or it may be caused by an inflammatory thickening of the conjunctiva, forcing the free edge of the lid away from the eye, the fibres of the orbicularis especially of that portion arising from the crista lachr. will constrict the swollen portion of the conjunctiva and force it and the edge of the lid outwards.

This latter variety requires only a returning of the lid to its normal position and keeping it there for a short time, till the engorged vessels have returned to their natural size, changing the bandage often, so as to keep the eye clear of the conjunctival discharge. The paralytic variety, found in old people, may result in great hypertrophy of the conjunctiva from the constant exposure; the vessels become engorged, and the conjunctiva assumes a fleshy appearance, *Ectropium luxurians*. The lid itself becomes longer, and in order to replace it, the outer canthus should be slit as in canthoplasty. A piece of skin should now be removed; it should be triangular in shape, its apex downwards, and the base joining the lower line of the incision. The whole lower lid should now be carried outwards and sewed to the extreme end of the incision; it becomes much shorter and will be kept easily in its proper place. The conjunctiva of the upper lid is now to be sewed to the upper line of the incision. This triangular or V-shaped piece may also be taken from the centre of the lid in its entire thickness by means of scissors. In this case the edges must be brought together with great precision, as very often a small indentation of the free edge will remain causing the tears to run over at this point and to excoriate the lid and cheek. The size of the piece to be removed can be found best by seeing how much longer the lid is than the normal lid. If the outer canthus in a case of ectropium is very large, the outer edges of the lower and upper lid may be pared off for three or five mm. and sewed together.

Ectropium caused by contracting scars after injuries of the lids, after burns, or periostitis, are often very troublesome affections. Cutting the contracting bands, and thus freeing the lid from the cicatrix, and keeping it apart from it by means of dressings or even sutures, will fail in many cases to give relief, and often increase the deformity. The best plan is to remove the cicatrix with a triangular piece of skin and bring a flap from the neighboring tissues to cover up the defect in such a way as to crowd the lid into its normal position. No definite rules can be laid down for this operation, which will be different in almost every case we meet with.

Anchyloblepharon is caused if the edges of the lid, denuded of their lining membrane, lie in close apposition for any length of time, till they are united. This is sometimes the case in severe blennorrhœic processes of the conjunctiva. The acrid discharge produces excoriations of the edges of the lids; great swelling of the lids is apt to be present, so that the patient is not able to open his eyes for several days. Now, if this is not forcibly done, and the edges kept clean and protected by oil or simple salve, the lids may heal partly together. Severe burns of the eye, implicating both conjunctiva and lids, especially if caused by lime, are apt to result in total union of the lids. *Total symblepharon.*

Treatment.—Pass a director behind the adhesions and cut them with a knife or a pair of scissors; pull the lids apart, put oiled pieces of linen over the wound, and keep them in place by a bandage. This has to be renewed three or four times a day, till the cut edges of the lids have healed.

Symblepharon (Fig. VII.) is formed by the healing together of the conjunctiva of the lid to that of the eyeball, thus uniting eyeball and lid, to the impairment of their mobility. This union may be accomplished by a small band-like portion of the conjunctiva "*partial symblepharon,*" or by the whole, causing a *total symblepharon.* The cause of the symblepharon is always an injury affecting both parts of the conjunctiva, that of the eyeball and that of the lid, and this is mostly the case in burns, where the caustics, acids or alkalies, especially lime, enter the eye and remain sufficiently long. Burns of this kind are generally quite extensive; they cause much irritation and swelling; the eye may remain closed for a few days, and during this time firm union may have taken place. This of course might often be avoided by frequent instillations of a sticky oil, like the castor oil, which will keep the wounded surfaces apart.

The treatment of the symblepharon is very difficult if a large portion of the lid is adherent and especially if the adhesion extends to the bottom of the conjunctival sac.

If, as in many cases, the cornea is also affected and entirely opaque, or if more than half of the upper and lower lid is implicated, no operation should be thought of; if a portion of the cornea is free and clear it should be undertaken. Small bands may be easily cut with scissors, but great care must be taken to keep the wounded parts from coming in contact with each other; this is prevented by sutures, bringing the conjunctiva together and carrying a few sutures through the skin of the lid and drawing it away from the eyeball. Of greater difficulty is the operation when the process extends to the bottom of the cul-de-sac. In this case a piece of lead wire should be introduced at the very bottom of the adhesion and left here till a sinus covered with mucous membrane has been formed. The adhesion may now be divided and the parts separated by a fine piece of lead, which must be fastened to the lid by means of sutures. This must be kept in place till the cut surfaces have healed. If the adherent portion is very large, the conjunctiva from another healthy portion of the eyeball must be transplanted and made to cover the wound (Teale). Even the conjunctiva of the rabbit may be used for this purpose.

Trichiasis is an affection in which the lashes have an abnormal direction, turning inwards towards the eyeball; if there are two distinct rows of lashes, one normal, the other directed towards the eyeball, it is called *Distichiasis*. This latter affection may be congenital; in very rare cases it is the result of disease. Trichiasis is the result of a conjunctival or marginal affection, which results in changes, contraction, or hypertrophy of that portion of the lid which contains the hair bulbs; these will on that account grow in a different direction, and as they cannot very well penetrate the skin, they will grow towards the free edge of the lid. Entropium will greatly favor this condition. Trichiasis might be mistaken for entropium, but in trichiasis the normal lashes are in their normal position, only a number of them growing inwards, and the free edge of the lid is always to be seen. In entropium the edge of the lid as well as the lashes are turned inwards. Trichiasis may affect only a small portion of the lashes; they will rub against the conjunctiva and keep this inflamed, or they will rub against the cornea and cause an opacity (pannus), and greatly irritate the cornea; they cause sometimes blindness. In trichiasis the ingrowing lashes, wild lashes, may be stunted in their growth; they are of very light color and are easily overlooked. They can be seen best by drawing the lid away from the eye, and especially can they be seen by means of a magnifying lens.

Treatment.—The simplest, but by no means the best way of dealing with these lashes, is their removal by means of cilia-forceps, *epilation;* the points of the forceps ought to be perfectly smooth, or they will not remove the fine hairs; this requires a little skill or the lashes will break off; they are best removed by gentle traction and by seizing the cilia near to the edge of the lid. In obstinate cases, however, an operation should be resorted to. Of the numerous varieties of these, the operation of Jaesche-Arlt or that of Hotz are the most promising ones. The first operation consists of a transplantation of the hair bulbs, the second aims to give the margin of the lid a different direction, and is, therefore, also very useful for entropium. For the operation of Arlt a pair of lid-forceps of Snellen, or their modification by Knapp or Prout, have to be used.

After the application of the entropium forceps, the lid must be split on its free edge in two parts, the lower comprising the cartilage and conjunctiva, the upper the skin, muscle, and lashes. The incision must be about five mm. deep; great care must be taken to remove all hair bulbs, which appear as small black specks on the white cartilage, or the operation will not be successful. A horizontal incision is now to be made parallel with and about five mm. from the edge of the lid down to the cartilage; it must communicate with the incision made for the division of the lid. In this piece of the lid the hair bulbs are contained. A semilunar piece of skin is now taken out of the upper lid, and the edges of the wound are drawn together in such a way, that the inner and outer sutures enter under the flap of skin holding the lashes, and come out at the upper border of the incision of the lid. Drawing these sutures together, this piece of the lid is drawn upwards, leaving a portion of the cartilage exposed, and also a gaping wound between the flap, and the cartilage, which will fill up and heal by granulations. The central portions of the wound are also brought together by sutures. The effect is very marked in the beginning, but later contractions of the wound may partly destroy the effect. The end sutures must not be drawn too tight or they may strangulate the narrow piece of skin which holds the lashes. Sloughing of this piece is the greatest danger in the operation. The sutures should remain in for two or three days.

Hotz' operation is performed by fixing the skin of the brow against the margin of the orbit, seizing the free edge of the lid with the fingers and drawing the centre of this gently downwards, so that the fine furrow in the skin of the lid which begins two mm. over the inner canthus and forms a curve corresponding to the upper convex border of the tarsal cartilage, forms a straight white line. Following this, a straight incision extending from a point two mm. above the inner canthus to a corresponding point at the outer canthus, will correspond to the upper edge of the tarsal cartilage. The incision has to be carried through the integument and through the muscle to the aponeurosis of the cartilage, but care must be taken not to cut through the tarso-orbital fascia. A strip of the muscular layer, about three mm. in width, is now removed from the everted lower portion of the wound extending from the inner to the outer canthus. Great care should be taken to leave no muscular fibres on the upper portion of the cartilage. After all bleeding has been arrested, the edges of the wound are stitched to the aponeurosis upon the upper edge of the tarsal cartilage, in such a way that the suture includes the upper margin of the wound, a portion of the aponeurosis, and the lower margin of the wound, but no muscular fibres should be included. Four to five stitches will be required. The eye will have to be bandaged, and the stitches must be removed about the second or third day. This operation is very simple but quite effective, and does not produce any deformity nor shrinking of the skin.

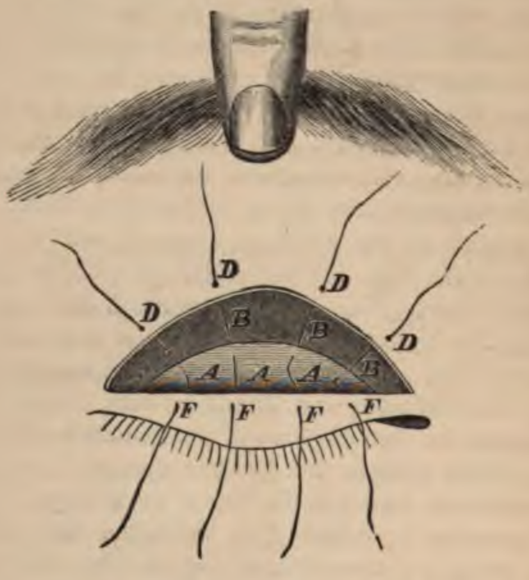

Fig. 1 Represents the application of the sutures. The lower border of the skin is pulled downward and the upper border upwards, to show the course of the thread through the aponeurosis. *F*, *F*, *F*, entrances of sutures into skin of lid. *A*, *A*, *A*, points of entrance, and *B*, *B*, *B*, points of exit in aponeurosis. *D*, *D*, *D*, *D*, stitch-holes in upper border of wound.

In all operations on the lids the following rules should be observed: after the operation has been completed, apply vaseline, spread on a soft piece of linen to the wound, and cover this with several layers of borated or absorbent cotton—and finally with a fine flannel bandage. Renew the dressing within twenty-four hours after the operation, cleanse the eye and apply a new dressing and bandage. This may be removed and left off entirely the second day after the operation; and the stitches can be taken out, if necessary, this time. By this method all swelling of the lids is avoided, the patient suffers less pain, and may leave the operating room and go to his home, if necessary. Healing by first intention is greatly favored by the absolute rest thus gained. If any conjunctival disease exists, frequent changes of the dressings are called for. Black silk alone ought to be used in operations on the lids; it is readily seen, and it is free from irritating, poisonous colors.

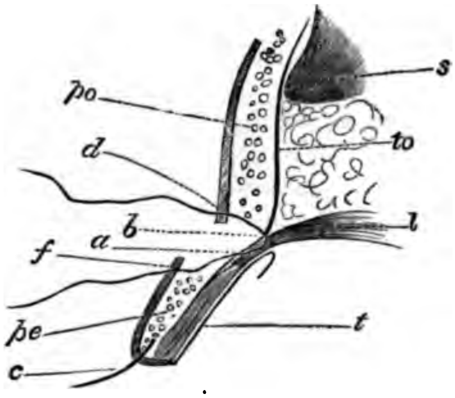

Fig. 2 Represents a vertical section of the eyelid; *s*, supraorbital margin; *to*, fascia tarso-orbitalis; *po*, pars orbitalis; *pe*, pars ciliaris of orbicularis muscle; *t*, tarsus; *c*, eyelash; *f*, lower border; d, upper border of the wound; *a b*, passage of suture through aponeurosis.

CHAPTER III.

LACHRYMAL APPARATUS.

THE lachrymal apparatus is composed of the organ secreting the tears, the lachrymal gland, and of a set of canals conducting the tears from the eye to the posterior nares. The lachrymal gland is an acinous gland, divided into two lobes, and is situated in a depression of the roof of the orbit near the outer canthus, behind the tarso-orbital fascia; here it is attached by fibrinous prolongations to the periosteum of the orbit. The larger lobe of the gland is flat, almond shaped; the smaller is separated from the first by a slight depression, and is lying nearest to the orbital margin, and is covered by a reflexion of conjunctiva. Seven small ducts carry the tears to the upper portion of the upper lid and open into the conjunctival sac at the middle and outer portion of the upper fold of transmission; from here the tear-fluid is distributed over the eye and collects near the caruncula lachrymalis at the inner canthus. From this place two small canals, *canaliculi*, with minute orifices, *puncta lachrymalia*, carry the tear-fluid into the lachrymal sac. The canaliculi are situated on the inner portion of the free edge of the lids. The upper one is smaller and shorter than the lower one; they unite near the lachrymal sac, and enter by a common opening, which lies behind the internal canthal ligament. The canaliculi are composed of three different coats, an internal or epithelial coat made up of a deep layer of epithelial cells, a fibrous coat composed of dense fibrous tissue and an external or muscular layer. This is different in the vertical and horizontal portion of the canaliculi and absent in the common ducts. In the vertical portion, which is about 1.5 mm. long, and which ends in a funnel-shaped expansion, the muscular fibres are circular; they are derived from the ciliary portion of the orbicularis muscle. The horizontal portion, which is about six mm. long, is surrounded by longitudinal fibres of Horner's muscle. The lachrymal sac and the nasal ducts are continuous; the upper expanded portion is called the sac; it is located in a depression formed by the lachrymal and superior maxillary bones; it is covered by fibres of the orbicularis muscle, and an expansion of the tendo oculi; it is about ten mm. long, and is composed of a dense fibrous structure intimately connected with the periosteum of the underlying bones and lined with mucous membrane, which is continuous with that of the canaliculi on the one side, and the nasal duct on the other. Its posterior wall forms a straight line with the nasal duct, but the anterior wall forms a little pouch, formed by loose mucous membrane. In introducing a sound, it should therefore be passed along the posterior wall. The upper portion of the nasal duct is bony, and is located in the superior maxillary bone, seven to nine mm. long. The membranous or nasal portion is four to nine mm. long, opens on the outer wall of the nasal cavity, behind the anterior opening of the nostril, and about six to nine mm. above its floor, and lies in the mucous membrane. Its lining mucous membrane is continuous with that of the nose. The passage of the tears from the eye to the nasal passage is caused by the action of the orbicularis muscle.

The lachrymal gland occupies a well protected place. Injury and disease of the gland are therefore rare. It may become inflamed, and presents in these cases a very painful, inflamed tumor near the outer canthus, pressing the eyeball downwards and inwards. The inflammation generally ends in suppuration, and the abscess breaks through the integument near the outer canthus. Incision ought to be made as soon as possible and exit given to the matter.

Destruction of the gland or removal of it does not produce a dry condition of the eye, because the glands and the mucous follicles of the conjunctiva are sufficient to keep the eye moist.

A fistulous opening may remain after an abscess of the gland, from which tear fluid will flow. If touching with nitrate of silver will not close it, a thread of sewing silk should be passed through the fistula and the conjunctiva of the upper lid, and kept in place till a sinus leading into the conjunctiva has been established, which will carry the tears into the conjunctival sac, when the outer opening can be made to heal. A dislocation of the gland occurs sometimes as a congenital condition, and is usually found on both sides. A freely movable tumor depresses in such cases the outer portion of the upper lid. On examination a depression on the roof of the orbit can be felt, to which the tumor is more or less firmly attached. It may be advisable in such cases to remove the glands for cosmetic effect; this may be done without injurious effect to the eye.

Malignant tumors will sometimes take their origin in this gland; a hard nodular mass near the outer canthus, with early induration and discoloration of the skin, would lead us to think of a cancerous growth. In most cases, however, the gland becomes secondarily affected.

The opening of the small ducts of the gland leading to the eye may become closed, the result will be a distention of the duct forming a small bluish tumor of the size of a pea (Dacryops) which can be seen bulging and shining through the conjunctiva on everting the upper eyelid. Excision of a portion of the cyst wall, or the introduction of a fine silk thread through the cyst and through the lid will speedily destroy it.

Lachrymation is an increase of the tear fluid, caused by reflex action due to irritation of one of the ciliary nerves, or of one of the sensitive nerves of the conjunctiva. It is caused especially by foreign bodies and superficial inflammation of the eye. *Epiphora* or watery eye is a condition brought about, either by an excess of secretion of tears, or by an impediment to the flow of tears from the eye to the nose, *stillicidium lachrymarum*. The first condition may be due to an irritable condition of the lachrymal gland, and is noticed after a great depression of the system by misfortune or by inflammation of the conjunctiva, for instance, in some form of catarrhal conjunctivitis, or by foreign bodies in the eye, or by corneal affections. More frequently epiphora is however, due to obstructions of the tear-passages. The tears cannot flow through it, but fill up the palpebral fissures and run over the cheek, especially when the eye becomes irritated by wind or dust. Any portion of the passage may be at fault. The puncta of the canaliculi may be prevented from reaching the tear fluid; eversion of the puncta lachrymalia. This may be due to an ectropium of the lids, or to any slight injury of the lower lids, resulting in retraction of the edge of the lid, or it is due to senile paralysis of the orbicularis muscle, resulting in a drooping of the lower lid, or it accompanies facial hemiplegia; it is also seen in old cases of blepharadenitis which produced thickening or destruction of the free edge of the lid, or in blennorhœa of the conjunctiva. In these the conjunctiva may become so thickened that it prevents the puncta lachrymalia from coming into contact with the tear fluid. It is often hard to remedy. If it is not possible to remove the cause, slit the canaliculus, by means of a canaliculus knife, to its entrance into the tear sac. The inner portion of the duct will then be able to carry off the tears. Inflammation of the canaliculi and the formation of strictures, due to this cause is of rare occurrence; but injuries in the region of the canaliculi will often lead to the formation of strictures and should be treated by slitting the canaliculus. Foreign bodies may obstruct the canaliculi, such as eyelashes and dust; they can be removed easily if they protrude from the opening. At times irregular enlargements can be felt in the canaliculi, and the puncta seem to be plugged up with a gray mass; this is an accumulation of small fungi of a leptothric variety. If they cannot be pressed out, laying open the canaliculi and using a mild solution of carbolic acid will be necessary. Strictures of the canaliculi, the result of an inflammation of the sac, are more frequently found near the entrance of the sac; they must be divided and kept dilated by the use of probes.

The lachrymal sac and the nasal duct are continuous, and are generally diseased together. We meet with three varieties of troubles in this region; they are, strictures of the duct, a chronic blennorrhœa and an acute inflammation of the sac.

Strictures of the duct. We have three varieties, mucous, fibrous, and bony strictures. They are generally the result of an inflammatory action in the sac. The starting-point of the inflammation is generally the nose, with which the lining membrane of the duct is continuous. The inflammation is apt to affect the mouth of the duct or extend upwards to the lower portion of the sac. The mucous membrane is at this latter place very loose and abundant; the opening of the duct is almost closed by it like a valve. Inflammation, with swelling of this membrane, accompanied by loss of epithelial cells, will bring two raw surfaces in close apposition. The result of it will be a firm union; this may also take place at the nasal end of the duct. These are mucous strictures. They can be easily separated and kept apart.

Fibrous strictures are due to a long continued inflammatory action implicating the outer fibrous layer of the duct. Ulceration of the mucous membrane takes place and leads to the formation of cicatricial tissue, with dense fibrous bands of various widths. We may encounter several of them in the same duct. If the process affects now the periosteum, the bone will also suffer and the opening of the lachrymal canal will become blocked up with the products of a slow inflammatory process until it is almost obliterated. The bone may become entirely denuded for some distance during the inflammation, and can be felt distinctly on the introduction of a probe. Bony strictures are generally hopeless ones, but we must try to establish an opening through the duct, and this must be kept open by the daily use of a probe. It is not infrequent that in the hands of a novice the point of the canaliculus knife breaks off. If such an accident occurs, and the point cannot be easily extracted, either because it is tightly wedged in between the bones, or because it cannot be felt, it is best not to irritate the parts by useless attempts at removal, the piece of steel left there will do no harm, it will be gradually absorbed, and will probably never trouble the patient.

Simple strictures are not accompanied by inflammatory signs. The tears cannot pass; they will collect in the sac, and may even produce a slight prominence of the sac. By gentle pressure a few drops of clear tear fluid can be pressed out through the canaliculi or through the nose. There is no pain, and the epiphora will be the only symptom that brings the patient to seek advice after suffering perhaps for years. On examining the patient we will find the eye of the affected side more watery than that of the other side, and there is generally a slight redness of the inner canthus caused by the overflowing tears.

Dacryocystoblennorrhœa, or blennorrhœa of the tear-sac, Lachrymal catarrh.

Inflammatory conditions of the lining membrane of the nose are perhaps the most frequent of all the causes of inflammatory actions in the tear passages, but an inflammation of the conjunctiva may also descend through the canaliculi to the sac.

This has been called the vicious circle. How often do we not see diseases of the conjunctiva or cornea, especially those that are accompanied by lachrymation, followed by inflammation of the Schneiderian membrane: and on the other hand, mild forms of conjunctivitis generally accompany catarrhal inflammation of the nose or the tear sac. An inflammatory process affecting the sac will soon be followed by thickening of the lower portion of its lining membrane. Here the peculiar arrangement of the mucous membrane favors an obstruction of the duct. This will be followed by retention of the tears and of the inflammatory products, which in the beginning of the process, or in very mild cases of the disease consists only of a thick viscid mucus (mucocele). This results eventually in a distention of the sac. The contents of the sac are in the beginning easily pressed down to the nose through the partly obstructed duct. Later, the closure of the duct becomes complete, the contents of the sac cannot be pressed down the nose, but will escape through the canaliculi into the eye. As the irritation of the products, composed of decomposing mucus, epithelial cells, and tear-fluid on the lining membrane of the sac is continued, it will soon be followed by the appearance of pus, and the muco-purulent matter being forced back into the conjunctival sac, will irritate this and set up a conjunctivitis; the edges of the lids participate and blepharitis ciliaris is added to the patient's troubles. This septic material becomes very dangerous if it happens to be present in ulcerations of the cornea or wounds of the eye, and before we operate on such an eye, for instance, for cataract or make an iridectomy, we must take care to remedy this trouble first. In ulcerations or wounds of the cornea we must likewise lose no time in operating on the sac, if this is inflamed. The picture of such an eye is now as follows; there is a mild conjunctivitis affecting generally the inner angle of the eye, complicated at times with blepharadenitis. There is lachrymation, and a small tumor near the inner canthus; the tumor may be present only in the morning, as the patient soon learns to press out the discharge as soon as it forms during the day. The eye is glued together in the morning by the evaporation of the muco-purulent matter. The patient is obliged to remove the tears and the mucus constantly during the day. Slight dimness of vision is often complained of; it is generally due to the presence of mucus on the cornea, which is easily removed by rubbing the eye; slight excoriations, with itching of the inner canthus is another symptom. Before such a condition is reached it may take many years, but at times the process is more acute and develops rather quickly. It is of frequent occurrence in this country, like all diseases due to nasal catarrh; but it is greatly favored by a strumous condition of the patient, or that peculiar flat, broad nose found in patients affected with congenital syphilis. Every now and then such eyes will become inflamed on the least exposure, the lids begin to swell and may remain closed for several days, local heat and tenderness is complained of by the patient, but the pain is not very severe, and in a few days the swelling will subside, leaving the eye in the same condition as described before.

Dacryocystitis, Lachrymal abscess, Fig. I. pl. 1.

The preceding symptoms may have existed for some time without the patient doing anything for their relief, when suddenly the canaliculi at their points of entrance into the sac become closed up, through an extension of the inflammatory action to this part. This is generally caused by a fresh cold or by are duced state of the patient's health. In other cases the lower portion of the sac, as well as the entrance of the canaliculi, may become closed almost simultaneously by a more acute process.

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inflamed mucous membrane. The products of the inflammatory process become more and more crowded together, distending and irritating the sac. The deeper structures of this as well as the surrounding tissues become likewise affected, great swelling, caused not only by the distended sac, but also by the infiltration of the surrounding tissue, becomes the most prominent symptom, and the œdema of the lids will produce complete closure of the palpebral fissure. This may resemble erysipelatous inflammation very much, on account of the tension, the local heat, and the general febrile symptoms, so closely that it is often mistaken for it; but in this affection the pain is more severe than in erysi*pelas*, and the swelling will seldom extend to the other side of the nose or reach the hair. The pain complained of is often reflex, extending as far back as the temples and the back of the head; but there is also great local pain when the sac becomes distended to any extent.

The inflammatory action will ultimately result in a breaking down of the sac and the surrounding tissue in the formation of an abscess. The process may now come to a standstill, the contents of the abscess may become gradually absorbed, the swelling and redness will disappear, but the canal remains closed, and the epiphora continues as before, because the tears cannot pass through the shrunken sac. But by far the most frequent course of the disease is the breaking down of the integument. The abscess will discharge through the skin and leave a large deforming scar after it heals. At times the swelling and inflammation will subside very rapidly after the breaking of the abscess, and also the thickening of the mucous membrane of the canaliculi will go back and the tears begin to pass into the sac before the external opening has healed; the tears will run through the opening constantly and prevent its closing up; a fistula of the lachrymal sac has been formed. This very troublesome condition is of much more frequent occurrence than the formation of a fistula of the lachrymal gland, and is more obstinate in its treatment.

The treatment of all these affections of the lachrymal sac and duct are more complicated than that of the diseased canaliculi. It is not only necessary to slit these in order to get access to the sac, but the knife has also to be passed through the sac; constricted portion has to be freely divided, and has to be kept fully dilated during the time it heals. In operating on the sac for simple stricture, for chronic blennorrhœa of the sac and also for an acute attack, it is best to select the lower canaliculus, because after this has been laid open the tears will enter it easily, and will be more readily carried off. In order to facilitate this as much as possible, the opening made into the canaliculus should lie in the conjunctival or inner side of the lid, so that, whether the eye is closed or open, the opening is in contact with the tear-fluid. The knife in cutting the canaliculus must therefore be held not only upwards but also slightly inwards, never outwards, or the tears would never be able to get into the newly made channel. In many cases, however, even if the incision in the canaliculus lies too much on the surface of the lid, the tears can pass into the sac at the inner canthus. As we have to cut the internal canthal ligament in this operation, the lid will drop somewhat afterwards, which will cause a sinking of the caruncle. The entrances into the canaliculi may be difficult to find, from the fact that they are changed by inflammatory actions or partly atrophied from non-use. Should this be the case, take an ordinary pin and introduce the sharp point into the punctum and stretch it, until it will admit the point of the knife. The point of the knife should, therefore, not be too large and round, a beak-shaped point of small dimension is preferable. The knife itself should not be too small or the strictures cannot be completely divided. Dr. Noyes' or Dr. Agnew's modifications of Weber's knife are very good on this account. If it is impossible to get into the lower canaliculus, the upper one must be opened. On doing this operation, sit in front of the patient, because you can see better what you are doing and can control the patient more satisfactorily. Put the lid well on the stretch by placing your hand over the patient's face and pulling with your thumb the lower lid of the patient down and outwards, and enter the punctum by pushing your knife gently downwards. After your knife has entered the canaliculus, continue the stretching of the lid and push your knife in an upward and inward direction without cutting the canaliculus, till we get into the sac and feel the inner bony wall. Now elevate the handle of the knife to a vertical line running nearly parallel with the outer wall of the nose, and thus cut the inner and upper portion of the canaliculus. After this has been completely divided, release your hold on the lid, and hugging the inner wall of the sac, push your knife down till it goes through the stricture or strictures and divides them freely. Hold the cutting edge of your knife forwards and push it down and outwards and a little backwards. The blood flowing from the nose or mouth, or the coughing and spitting of blood, is the best proof that you have divided the stricture and restored the opening of the previously closed duct. A large-sized sound should now be taken and passed through the canaliculus and sac, and through the divided stricture. This will check the bleeding at once and dilate the stricture completely. I generally use a No. 8 or No. 10 lachrymal probe, if I feel that the diameter of the nasal duct is large. In introducing the probe or on dividing the stricture, remember that in order to get into the sac we must follow the direction of the canaliculus; the knife or probe must be directed from the malar portion of the orbit to the inner canthus, and lifting the knife or probe after touching the septum of the nose, we must not attempt to push them down into the sac until we have brought the knife to an almost vertical line, which running downwards, points to the corresponding corner of the patient's mouth. The probes used for this purpose are known as Bowman's probes, they are made of pure silver or hard rubber.

The next day this same probe (No. 8) should be used again; after this the introduction of this size of a sound, or even a larger one, should be continued every other day, till we have reason to believe that the wound is perfectly healed and the probes continue to pass freely. It is seldom that, when using these precautions, we have rapid contraction of the divided strictures take place, or have an inflammatory action set up, in which cases we should be obliged to introduce smaller probes, and later on have the size of the probes gradually increased again. Should erysipelatous inflammation attack the wound, it is well to discontinue the probing, but instead of it cover the whole inflamed surface frequently and freely with collodion, give muriated tincture of iron, and do not commence with the probes until after all inflammation has entirely disappeared. Very troublesome ecchymosis of the lids, continuing for days, may follow the operation. It is prevented by the application of ice, or of a mild solution of common table salt, a teaspoonful to a pint of cold water, to be applied very freely during the first day. The only application needed after the operation is the use of a mild astringent such as pulverized tannin, or a strong solution of alum, twenty grains to one ounce of water, applied to the inner canthus. The patient must be directed to press out the accumulations in the sac several times a day, and after this is done he must blow his nose very hard so as to clean the duct as much as possible; this will naturally draw the astringent applied to the eye, downwards, and thus it comes in contact with the diseased lining membrane of the sac as well as if it had been applied with a syringe made for this purpose.

Most of these cases will make a very good and speedy recovery, the eye will appear weak and remain easily irritated for some time, but the use of an astringent like alum, ten grains dissolved in two ounces of camphor water, will give great relief. It may become necessary to introduce the sound every few months for those cases in which the stricture shows the slightest tendency to contract again. In some cases there will be more or less lachrymation even after the operation, especially after an old chronic process affecting the bones or resulting in great changes of the mucous membrane. In these cases a mild astringent of a solution of five grains of sulphate of zinc to two ounces of water, or five grains of boracic acid to one ounce of water, or an excellent preparation composed of two grains of nitrate of silver, twenty grains of glycerite of tar, to one ounce of water may be introduced into the sac by means of a small syringe with a long flexible point of metal which can be bent slightly and introduced into the sac. The old custom of introducing lead wire (styles), and leaving it to remain in the ducts for many weeks, does very little good, is annoying to the patient, and may cause deep sloughs. It is, therefore, very little used now.

In cases of acute inflammation of the sac, leading to the formation of an abscess, the treatment will vary a little. The parts may be swollen, so that it will be impossible to find the opening of the canaliculi, or the integument over the abscess may have become affected to such an extent that it is very thin and greatly distended; in these cases an incision into the abscess should be made with a scalpel, beginning a little under the canthal ligament and running downwards and a little outwards along the nose, so as to prevent the formation of an ugly cicatrix; after opening the sac and removing the contents, probes should be passed through the nasal duct so as to open this and prevent the formation of a fistula of the sac. As soon as possible the canaliculus should be slit, the opening of the abscess allowed to heal, and the case treated, as mentioned above. Cases of fistula should be treated in the same manner and by touching them also with nitrate of silver. In old cases of a fistula a probe of hard rubber with a broad short handle (Noyes), may be left in the canal for a few days, and if necessary the opening of the fistula should be touched with the nitrate of silver. Very obstinate cases of fistula or inflammatory processes of the sac call for an extirpation of the sac. This is best accomplished by a large incision through the outer wall of the sac, and exposing the inside of it, which should now be thoroughly treated with the actual cautery. The wound is now to be closed up again. This gives great relief, the epiphora improves in most cases at once and it is very rare that an extirpation of the lachrymal gland will have to be undertaken for this trouble. It is of rare occurrence that polypoid masses spring up from the lining mucous membrane of the tear sac. In case they should occur, they will fill up the sac entirely in the course of time, causing marked epiphora, but we are unable to press any tears or matter from the sac, which presents a hard elastic swelling. If operated upon by means of the canaliculus knife, the operation is accompanied and followed by copious hemorrhages, which will be renewed at each introduction of the sound, till the polypoid masses have disappeared. In such cases a strong injection of a solution of nitrate of silver, two grains to one ounce of water, or a solution of sulphate of zinc, five grains to one ounce of water, introduced by means of a lachrymal syringe is of good service.

As the lachrymal troubles are of frequent occurrence, I would advise once more to operate for them as soon as possible, as long as the mucous membrane has not undergone great changes. Always operate and remove the trouble before an important operation on the eye is undertaken, and to use very large sounds, as large as will easily pass, immediately after the operation, and to use this same size probe also a day after the division of the stricture, and to divide the stricture freely by partly withdrawing the knife and introducing it again with the cutting edge in a different direction; also to use mild astringents immediately after the operation, and especially after the use of the probes, and cause the patient to draw these through the lachrymal canal by blowing the nose smartly.

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CHAPTER IV.

MUSCLES OF THE EYEBALL.

THE muscles of the eye may be divided into internal and external muscles. The internal muscles are those of the iris and the ciliary body. The external muscles form two sets; the first four are called the recti muscles, and, taking their origin from a point behind, their united action helps to keep the eyeball in the orbit. The other set, the oblique muscles, much weaker than the recti, take their fixed point anterior to their insertion into the sclera; their action alone would, therefore, draw the eyeball forwards, and this is exactly what takes place in a paralysis of the recti muscles—the eyeball becomes more prominent. The function of the external muscles of the eye is to move the eyeball, and by the harmony of their action with that of the muscles of the other eye, we are enabled to see an object with both eyes at the same time. Any disturbance of this harmony must, however, result in disturbance of vision. If the visual line of one eye deviates from that of the other eye, two images will be seen; one with the macula lutea of the eye whose visual line is directed to the object and another one seen by the deviating eye, which is not seen with the macula lutea, but with a more peripheral portion of the retina. This condition is called *diplopia*. The one image seen with the macula lutea appears sharp, well defined—it is called the *true* image; the other one seen with the deviating eye is not so sharp, it is blurred and indistinct—it is called the *false* image. It appears to be also at a different place than where it actually is; this is called *faulty projection.*

There are four recti muscles; they are the internal, external, superior and inferior rectus; they take their origin from a tendinous ring surrounding the optic foramen. The muscles are separated from each other in the orbit by the orbital tissue and by the optic nerve. The muscular fibres as they reach the tunica vaginalis near the equator of the eyeball pass very obliquely through it, and their sheath becomes intimately blended with it. After reaching the inner side of the capsule of Tenon they pass forward and are inserted into the anterior portion of the sclera. The portion of the tunica vaginalis anterior to the equator is called the capsule of Tenon, and posterior to the penetrating muscles is called the capsule of Bonnet.

The muscles spread just before reaching the sclera, and their insertion is a broad one. The point of insertion is from six to nine mm. from the sclero-corneal junction, that of the internal rectus lying nearest to it. There is some anatomical difference in the recti muscles; some of them are considerably shorter—the internal recti, others are longer—the external recti. This last muscle is supplied by the sixth or abducens nerves the other three recti are supplied by branches of the third nerve.

The oblique muscles, two in number, the superior and inferior, have a different origin, a different course, and different nerves supplying them. The superior oblique takes its origin also from the tendinous ring around the optic foramen, and passes forwards to the inner angle of the roof of the orbit, where it terminates in a round tendon, and runs through a ring of strong fibrous tissue which is attached to a depression in the orbital roof. Taking its point of action from this point, it runs backwards and outwards to the outer and posterior portion of the eyeball, where it has a broad insertion; it will therefore roll the eyeball downwards and outwards: it is supplied by the fourth or trochlearis nerve.

The inferior oblique takes its origin from a point anterior to the eyeball, from the superior maxillary bone, passes backwards under the inferior and external rectus, and is inserted into the posterior half of the sclera, between the superior and external recti; it must, therefore, roll the eyeball upwards and outwards. It is supplied by a branch of the third or motor oculi nerve.

The movement of the eyeball is, however, a very complex one, which is due to the oblique direction of the orbit. Only the rectus internus and externus act on a perfectly straight plane; they will, therefore, move the cornea either directly in or outwards: the superior and inferior recti, however, their origin being nearer to the median line of the body than their insertions, draw the eye not only up or downwards, but also a little inwards. In order to draw the eye directly up or downwards, another muscle must act conjointly with these recti muscles, and this is one of the oblique muscles. Looking upwards and inwards, or in similar movements, the act becomes more complicated, and requires the co-operation of three muscles; looking for instance, downwards and inwards, the action of the internal and inferior rectus, and also of the superior oblique is required.

If the action of both eyes together is to be studied, we find that an inward movement of the one is always accompanied by an outward movement of the other; the muscles of the two eyes acting in this way are called yoked or conjugate muscles. The action of the conjugate muscles must be in perfect harmony; the impulse given to the one, must cause the other conjugate muscle to act just as much as the other. A disturbance of the harmony of this action must cause a deviation from the line of vision; it may be due to want or excess of power of action of one muscle of the eye, and is called *primary deviation*, and will result in squint and diplopia. If one of the conjugate muscles is weaker than the other or paralyzed, requiring a greater effort to make it perform its duty than the other, this same effort, exerted on the conjugate muscle, will make it contract considerably more; the result will be an abnormal direction of the other eye, *secondary deviation*.

The blood supply of the muscles is derived from the two muscular branches of the ophthalmic artery; these branches give off later the anterior ciliary arteries.

Disturbances of the muscular apparatus may be due either to a paralysis of the nerves, to an insufficiency, to an excessive contraction, or to a disturbance of the harmony of two muscles.

MUSCULAR PARALYSIS.

Paralysis of the external muscles may be complete, affecting all of them, implicating the third, fourth, and sixth nerves. This is rare. Or all the muscles supplied by one nerve or only a portion of these muscles may be affected. We may have to deal with a complete paralysis, or only a paretic affection of a muscle; the latter may precede or follow a paralysis. In these cases a want of power in the muscle is noticed only during an extreme movement, requiring a great effort of the muscle, or after the muscle has been tired out by work. Paralysis of the muscles may, however, come on quite suddenly. Violent emotions will frequently bring on an attack. In these sudden cases no premonitory symptoms may have existed, but frequently the patient has been suffering from severe attacks of headache for some time, when, waking up some morning, he will find himself unable to get up, on account of the muscular disturbance caused by a paralytic attack. At times the paralysis of the ocular muscles may precede more extensive troubles of other parts of the body; again hemiplegia may occur simultaneously with the ocular paralysis.

This is of course due to the extent and nature of the lesion which causes the paralysis.

The *causes of paralysis* are peripheral or central, and the lesion affects generally the nerve, although at times the muscle itself may be the seat of the trouble, as, for instance, in injuries and wounds of the orbit, and especially by pressure of fragments of bone. Hemorrhages and cancers or inflammatory processes in the orbit may extend to the muscles, or cause pressure on the nerve.

Colds and exposures, causing a rheumatic inflammation of the nerve-sheath may result in paralysis. A frequent cause is syphilis in one shape or another; if the cause is a peripheral one, it is usually a specific periostitis of the sphenoidal fissure; of the central causes due to syphilis, we have localized basilar meningitis of which the paralysis may be the principal symptom; also gummata in the neighborhood of the origin or near the course of the nerve; locomotor ataxia is sometimes found to cause an attack of paralysis of one muscle during its first stages. Sudden attacks are generally due to small hemorrhages and are often found to be associated with heart lesions.

Paralysis of the third nerve with hemiplegia of the other side is said to be due to a lesion of the crus cerebri of the side of the affected motor oculi. Frequently the cause is very obscure.

Symptoms of paralysis.—The most striking symptoms of a paralysis are (1.) *inability to use the muscle;* when the patient is told to move the eyeball in the direction of the affected muscle, he cannot do it. The corresponding muscle of the other eye, the conjugate muscle, will act as usual, and the contrast between the two eyes will reveal the nature of the trouble at once. The best way to examine the patient for a muscular paralysis, is to direct him to look with both eyes at an object, such as our finger; this he has to follow with both eyes in all the different directions that it is moved, without moving his head; he ought to be able to follow it easily around an entire circle described by the examiner's hand. The position of both eyes should be watched during this time, and care should be taken to see whether the eyes are turned completely to the inner or outer canthus respectively. The corneal margin must come up to the outer canthus during an outward movement. Even slight cases of paralysis can be detected in this way.

Another important symptom is (2.) *diplopia*, or double vision. This is usually very annoying to the patient, even before other symptoms have manifested themselves. Whenever an object is moved over to the side of the affected muscle, the diseased eye cannot follow in this direction, and the object is seen with a peripheral portion of the retina; it appears dim and out of place; it is called the false image. The fellow eye is, however, not impaired in its movement, and sees the object plainly and distinctly with the macula lutea; this is the true image. If the paralysis is slight, the two images are not far apart, the second image may appear like a shadow of the first; the farther off the object is, the greater will be the distance between the double objects. Moving the object farther over to the affected side will also increase the distance between the images. According to the muscle affected, there will be a change in the relative positions of the double images; for instance, if the external rectus is paralyzed, and an object—the light of a candle is best suited for the purpose—is moved over to the affected side, outwards, the patient will begin to see two lights. In order to ascertain which image belongs to the unaffected and which to the affected eye, let the patient look through a red glass with the good eye; he will now see a red light with this eye and a white light with the affected eye. In the case of a paralyzed externus, the affected eye will not move outwards, the associate movement of the other eye will make this turn inwards towards the nose a convergence will take place and in this case the patient will see the red light on the right side, if the right eye is the good eye, and a white light on the left side; this is called *homonymous diplopia.*

Crossed diplopia will be caused by a paralysis of the internal rectus. If the light in these cases is moved in the direction of the affected muscle, a divergence will be produced by the action of the unaffected eye, and in divergence, the picture, seen by the affected eye, will be on the opposite side. In making these examinations, it is better to cover the good eye with the red glass, because the image seen by the affected eye is seen peripherally, and therefore not very distinctly, and it would be less so, if the patient looked with this eye through a colored glass. The double images differ in position according to the paralysis of the muscles, as said before, the image seen by the affected eye is not so distinct and is frequently not vertical but is more or less inclined. In paralysis of the internal and external recti muscles the two images are parallel; in affections of the superior and inferior recti, they are one over the other, and in paralytic conditions of the oblique muscles the images are inclined towards one another.

Binocular diplopia is, perhaps, the most important symptom of paralysis; monocular diplopia is entirely different, it is due to opacities of lens or cornea. Diplopia is seldom present in a case of squint, for if it has been present, the patient soon learned to suppress the second very annoying image and sees now only with the unaffected eye. It is absent in only very rare cases of paralysis; if, for instance, the affected eye has been squinting for some time, or if the paralysis is very marked, so that the patient has to use a very peripheral portion of the retina to see with, which will render the image so indistinct, that it is easily overlooked by the patient.

(3.) *Faulty projection* of the eye. The patient has always seen with the macula lutea; now the objects on the side of the affected muscle will be seen with a more peripheral portion of the retina, because the patient cannot turn the eye in that direction; the object appears, therefore at another place. Walking on the street for instance, he may think he is far from the curbstone, when in reality he is at the very edge of it. How do we examine him for this? Covering the good eye, we tell him to touch an object held in front of his eye promptly with his finger: he will not be able to do it, except after repeated efforts; he will reach over to one or the other side of it. This explains the feeling of dizziness and uncertainty that patients complain of in severe cases of paralysis.

(4.) In any attempt of the patient to move his eye in the direction in which the paralyzed muscle has to act, the neighboring muscles will assist in the movements, causing a peculiar oscillating movement of the eye.

(5.) Position of the head.—In order to avoid the annoying diplopia, the patient soon learns to hold his head in a direction which will favor the paralyzed muscle as much as possible, so as to avoid the necessity of using it.

(6.) *Secondary deviation.*—If the hand is placed over the healthy eye in such a manner, that the eye can be observed while the patient is made to look with the affected eye at a given object, say the finger, moved in the direction of the paralyzed muscle, he will make a great effort to do so; this effort is felt and responded to by the conjugate muscle of the healthy eye, and it will carry this eye much farther from the normal direction of the eyeball, causing this eye to squint even more than the paralyzed eye did before; this is called secondary deviation. In paralysis the secondary deviation of the unaffected eye is greater than the primary deviation of the affected eye.

7. *Squint.*—If a muscle has been paralyzed for some time

its opponent will soon make its preponderance felt and draw the eye towards it. This contraction of the opponent will become permanent and the result will be a squint, convergent in a paralysis of the external rectus muscle, divergent in paralysis of the internal rectus. This is one of the sequelæ that is to be dreaded, as it will lead to more serious consequences; these are not only disfiguring, but the paralyzed muscle will be put constantly on the stretch, it will not be used and atrophy of the muscle is apt to follow in these cases; and even if the cause of the paralysis should be removed, the muscle could not respond and act, because it is too weak now. Not only the muscle will become useless, but the sight of the eye will be impaired by this inactivity. The diplopia soon disappears in these cases, because the patient learns to suppress the faint second image; amblyopia from non-use will be the result. As long therefore, as we have diplopia we need not be alarmed for the sight of the affected eye.

8. *Exophthalmus* is a symptom which is only present if all the recti muscles, or at least all the three recti, supplied by the motor oculi nerve, are affected, it is never of a high degree, and is often accompanied by ptosis. The eye is immovable, which becomes very striking by comparison with the other eye. The sight of the eye itself is not affected, unless it is accompanied by other changes, like neuritis; this may be due to the same lesions which cause the muscular paralysis. Even in a paralysis of the rectus externus the eyeball looks frequently very prominent, because a large portion of the sclera is exposed by the contraction of the internal rectus.

Differential diagnosis of the paralytic affections of the different muscles:

Rectus externus, abducens paralysis. The eye cannot be rotated outwards; if complete, eye cannot be moved beyond the median line of the palpebral fissure. The diplopia becomes more marked in an outward direction and is generally absent if object is moved toward the nasal side. The double images are homonymous, upright, on same level and parallel, but if object is moved upwards and outwards, the false image is lower than the true one, downwards it is higher than the latter, it appears to be nearer to the patient than the true image. Results generally in inward squint.

Rectus internus, oculo-motorius paralysis.—Eye cannot be rotated inwards, diplopia crossed, more marked at nasal side; double images on same level, parallel and become wider apart if object is moved toward the nasal side. It is often associated with ptosis and mydriasis. Results generally in outward squint.

Rectus superior.—Eye cannot be rotated upwards, diplopia more marked in upper region, annoying if patient ascends a ladder or high stairs. False image diverging at top, higher than the true one, almost in one line, a little crossed. Results in downward squint.

Rectus inferior.—Eye cannot be rotated downwards; diplopia more marked in lower region, annoying in walking, especially descending stairs. False image converging at top, lower than the true one; a little crossed, false image appears nearest to the patient. Results in upward squint.

Inferior oblique, very rare. Eye difficult to rotate in an upward and outward direction. If an upward movement is attempted, the eye is carried up and inwards, by action of superior rectus. Diplopia homonymous; double images one almost above the other, inclined; if object is moved toward healthy eye, the difference in height increases, if moved to side of afflicted eye, the images become more inclined. It does not result in pronounced squint.

Superior oblique, Trochlearis paralysis.—Eye cannot be rotated downwards and outwards; diplopia homonymous below horizontal line, double images converge at top, the false image stands below the true one, distance greater in a downward and outward direction, therefore very annoying in descending stairways. Eye cannot be rotated downward as far as other eye, and an attempt to look downwards results in a downward and inward movement. Does not always result in squint.

The paralysis of the external rectus, or abducens paralysis, is perhaps the most frequent; a paralysis of the oblique, and especially of the inferior oblique, is very rare. A paralysis of the motor oculi may affect all of the muscles supplied by it, and in this case, ptosis is apt to be present, or it may affect only one or two of them; that of the internal rectus alone, is often seen. The paralysis may, after developing gradually, disappear again gradually, and result in complete recovery; this is often seen in those cases due to peripheral causes or in locomotor ataxia. Frequently, some slight defect of the muscle will remain, causing either a very slight squint, or show itself by pain after using the muscle—*muscular asthenopia*,—or by a slight diplopia in the extreme range of the muscle. Had the paralysis existed for some time, and favored contraction of the opponent, this may remain in that state even after a cure of the paralysis, and cause a concomitant squint; but more frequently it is a more unfortunate condition, the paralysis continues and causes more or less atrophy of the paralyzed muscle, and permanent contraction of the opponent,—*a paralytic squint*,—this is generally a very marked deformity.

Treatment. According to the causes of a paralysis the treatment must vary. In cases of orbital growths or in pressure on the nerve, the cause ought to be removed if possible. In many cases the ocular paralysis is only an insignificant complication of severer diseases, and hardly needs special attention. In a number of cases, where we have to deal with syphilitic affections, these are tertiary manifestations, and the use of large doses of Iodide of Potash is called for. The dose, small in the beginning say, ten grains three times a day, must be rapidly increased until the beneficial effects of it are felt.

One drachm may be given three times a day in many cases, without unpleasant symptoms. If given in such large doses, it should always be well diluted, and should be mixed with a bitter tonic, such as the Tincture of Gentian, as it would be apt to disarrange the stomach. ℞. Potass iodid. ℥ss. tr. gent. comp.; aquæ āā ℥iss. Dose: A teaspoonful in a wine-glass of water, one hour after meals. Should unpleasant symptoms of Iodism manifest themselves, such as salivation and papular eruptions, the medicine must be discontinued for a few days, or the Iodide of sodium may be given instead of it. The dose of the Iodide of sodium may be considerably smaller. In obscure cases, especially if there is a rheumatic tendency, the Iodide of potash must not be given in such large doses, six to ten grains three times a day will be sufficient. Of the greatest value, however, is the use of electricity. It should be applied every other day, for ten or fifteen minutes, the negative pole placed on the back of the neck, the positive pole over the affected muscle. The faradic current must be used; even if this does not affect the central cause, it may exert a beneficial effect on some of the peripheral causes, and it will prevent atrophy of the muscle, so that it can act promptly if the cause has been removed by other means. It is also of great value to exercise the muscle as much as possible, as soon as the muscle begins to act again. This is greatly facilitated by closing the healthy eye, and forcing the affected muscle to act. This should be done frequently during the day, but not too long at a time so as to tire the muscle, which would cause pain in the affected muscle and general headache.

The use of Strychnine is of advantage, especially hypordermically administered to the temples in daily and rapidly increasing doses from one thirty-second of a grain to one tenth of a grain, till the constitutional effect of the remedy is felt, by involuntary contractions of some muscle. The annoying diplopia is overcome by the use of prisms. Prisms can of course only be used if both eyes have good vision, and the paralysis is not quite complete, so that the two images can be brought together. Let your patient look at a lighted candle, placed directly in front of him, about twelve feet off. He will now tell you, that he sees two lights a number of feet apart from each other; see now what prismatic glass is required in order to make him see only one light. This is done by holding the weakest prism necessary in front of the eye with the base in the direction of the weak or paralyzed muscle. If you find that a prism of 26° will bring the images together, it will be necessary to divide this for the two eyes, because such a prism would be too heavy for practical purposes. It is always well to favor the affected eye a little, to give it a stronger prism. If we find that a prism of 26° is the proper glass, give a glass of 12° to the good and of 14° to the affected eye, and let your patient work, read, write, or attend to his business with these glasses on for several hours every day. After using these glasses for a week or longer, when the patient finds that it is no longer difficult to unite the two images in one, a weaker prism must be used, till this can be again given up for a weaker glass, and so on till the diplopia disappears altogether.

For the paralytic squint, if there is no probability that it will difficult than it usually is, or if the muscle is weak, the result of severe constitutional diseases such as diphtheria, typhoid fever etc. In these cases it is only temporary and disappears when the patient has regained his strength. It may also be the sequel of a paralysis of the internal rectus muscle, or it may be a prominent symptom of neurasthenia (Beard) but it is most frequently met with in myopic eyes, especially if the myopia is of a high degree; such a person, if not aided by proper glasses, has to hold objects near to his eyes in order to see them distinctly, this causes necessarily great convergence, which is at the same time more difficult than usual, because such an eye is not globular but oblong, on account of the increase of the antero-posterior diameter of the eyeball, see myopia.

The frequency and difficulty of convergence necessitates great exertions of the internal recti which at last become fatigued. This manifests itself after the eyes have been used for a short time by the sensation of heat and dryness of the eye, by pain in the eye and forehead, by lachrymation and by dimness of the objects, till at last one eye moves outward; after a period of rest these symptoms disappear and the patient is able to use his eyes again until after a shorter period of work the same symptoms return. This is called *muscular asthenopia*. After some time the dimness and even diplopia may become more annoying and the patient, in order to suppress this, learns to use only one eye, while the other not called upon to converge, will gradually diverge and develop into strabismus divergens. The diagnosis is easily made if the patient is directed to look at a fine point, for instance that of a lead pencil, and this being held at some distance, in front of his eyes a little lower than his nose, is gradually moved nearer and nearer to his eyes, the weaker of the two muscles will give out first, and the eye will suddenly turn a little outward, and only one eye will fix the point. Another way is to have both eyes moderately converged, by making the patient look at a point, six or eight inches from the eye, and covering now suddenly one eye in such a way that it cannot see the point, when this eye, if the internus is weak, will slightly change its position, and resume the first position again if the obstacle is removed. The most reliable test however is by the use of a prism, which placed before one eye will, by producing two images, avoid the necessity of convergence and show therefore the slightest amount of insufficiency.

The prism must be held with its base up or downwards before one eye and the patient must look at a line with a large dot on it. Does he now see two dots on one line, his interni are good, does he see two parallel lines and one dot on each of them, he has weak interni. The weaker the muscles, the greater will be the distance between the two lines. The weakest prism held now before the first prism, with its apex directed outwards, which brings the two lines together again, expresses the degree of the insufficiency.

Treatment.—Rest of the eye will give temporary relief, but as the principal cause of the trouble lies in the excessive convergence of myopic eyes, proper glasses, to remove the far point to a sufficient distance from the eye, should be used, for near work. Good illumination is also of great importance, as insufficient light necessitates close application of the eyes. Electricity, especially the galvanic current, has a good tonic effect on the weak muscles. The use of prisms combined with the proper concave glasses and systematic exercise of the eyes with these glasses gives great relief especially in mild cases; they may have to be used for a long time. In very severe cases, where the asthenopic troubles are very marked, and especially when there is a steady increase of the myopia, an operation, a tenotomy of the external recti, is of great help. This has to be done very carefully; the insufficiency should be measured by prisms and the extent of the operation should correspond to the strength of the prism required.

Abnormal contraction of one muscle produces a disturbance of the harmony of vision. A deviation from the line of vision, due to this cause, is called *squint*, or *strabismus*. Strabismus is the inability of the two eyes to fix one object at the same time centrally. The visual axis of such eyes are different, one fixing centrally, the other peripherally. There will therefore be diplopia in the beginning of squint; but as this generally occurs in early childhood, we hear hardly ever any complaint about it, because the patient will suppress the false image. This is necessary for the comfort of the patient, but it is the source of great danger to the sight of the squinting eye, which from non-use will become weakened, till at last it will see but very little, (Amblyopia.)

The chief danger of squint is therefore not for the good looks of the patient, but for his eye sight. This kind of squint, due to an abnormal contraction of a muscle is very different from squint caused by paralysis of a muscle and its treatment and prognosis differs materially. It is called concomitant squint. We have different varieties of squint: strabismus convergens, divergens, sursumvergens and deorsum vergens, according to the direction of the eyeball; strabismus alternans we call that condition where both eyes turn alternately, this proves that the contraction of the muscles is not permanent, and is entirely different from the condition of a paralytic squint. We meet also with cases where the squint is not permanent, only periodical. This is frequently the case in the beginning of strabismus, it may effect the patient if he is looking at distant or near objects, but is apt to be very evident when the patient does not attempt fixation; any effort of fixation may remove it entirely. *Strabismus convergens is* by far the most frequent of all the different varieties. *Causes:* the contraction of the muscle is supposed to be due, according to the notion of the patient, to convulsions, to falls, to whooping cough, measles, or scarlatina, fright or from looking at other children with the same trouble. Now, we know that the principal cause is a different one, that it is an unequal refractive error or an unequal visual power of the eyes; but still there is often some exciting cause, and this may be a weakened accommodation due to sickness or a nervous shock. As I said before, an unequal error of refraction of the two eyes is most frequently met with, especially in hypermetropia. There are two functions of an eye that are intimately associated; it is accommodation and convergens. In hypermetropia where accommodation is required, even for the distance, a much greater effort is required for near objects; the greater the degree of hypermetropia, the greater the effort of accommodation and the greater the impulse for convergence. If both eyes differ in this respect, the eye with the greatest amount of hypermetropia will require the most powerful accommodative effort and this will cause the greatest convergence, and the difference of the visual axis is at once established. This squint is therefore called concomitant squint, as it is so intimately associated with accommodation. These great efforts are followed by great development of the muscle, which now gains great preponderance over its antagonist, the external rectus, and the deviation, that in the beginning was only accompanying accommodation, becomes now permanent. If the visual power of one eye is less than that of the other eye, it requires greater efforts to see near by than the other eye needs, and we have here again an unequal call for convergence, the cause of squint. It develops generally in early childhood, but may develop later in life, even as late as twenty years after birth. But most cases of squint we meet with, that develop long after childhood, are cases of paralysis. *Strabismus divergens* is next in frequency to strabismus convergens. Its development is greatly favored by the insufficient interni of myopic eyes of high degree; great convergence of both eyes at the same time is almost impossible and the patient learns to use only his best eye, turning the poorer eye, usually that with the highest degree of myopia, outward, till the rectus externus gets into a state of tonic contraction and the divergent squint becomes permanent. In cases of unequal sight of the two eyes, if the one eye sees very little or is entirely blind, the impulse of convergence is entirely absent and the eye stands usually in the direction of the orbit, looking outwards.

Strabismus sursumvergens is due to abnormal development of the superior rectus; the patient squints upwards. *Strabismus deorsumvergens* is due to an abnormal contraction of the inferior rectus; the eye looks downwards.

These two varieties are generally caused by paralytic lesions. Milder degrees sometimes accompany strabismus convergens but seldom strabismus divergens.

Diagnosis and *Prognosis.*—As we have seen in the preceding lines, different causes may produce different varieties of squint. The differential diagnosis of these is easy, as the direction of the squint indicates which muscle is at fault.

It is important in regard to the prognosis, to differentiate between paralytic and concomitant squint. In periodical or alternating squint, the perfect action of all the implicated muscles becomes at once evident, and paralysis is easily excluded, but in show exactly the same amount of squint that the other eye had, in strabismus. In paralysis, as we have seen before, the great effort required to move the paralyzed muscle, will contract the conjugate muscle of the fellow eye considerably, and the squint will be *more intense* in the healthy, covered eye, than is shown in the affected eye. This secondary deviation is much greater in paralytic squint.

The degree of squint varies in different cases, the cornea does not reach the caruncle at the inner canthus in mild cases; it is partly covered by it in severe cases, and in bad cases the inner quadrant of the cornea and part of the pupillary space is hidden behind the caruncle. We can also measure the amount of squint by holding a rule in front of the eyes, and taking as a fixed point the bridge of the nose, we can easily measure the distance of each pupil from the central point; the difference indicates the amount of squint. This is of importance in regard to the prognosis. A mild case may sometimes be entirely cured by the use of glasses without an operation, or if an operation becomes necessary, simple tenotomy of the internal rectus will be sufficient to cure the deformity. In more marked cases division of the interni of both eyes may be necessary, and in very bad cases two or even three operations may be required to accomplish a perfect cure.

The prognosis of squint is good in uncomplicated concomitant, not so favorable in paralytic squint; milder cases of squint may be outgrown entirely, either by an increase in the accommodative power, or by a lessening of the optical difficulty in the squinting eye. A hypermetropic eye may become less so, or become even emmetropic or myopic; or the obstruction of vision, a macula cornea for instance, may clear up. The cause removed, the eye will often return to its normal position, but by far the most frequent occurrence is the permanence of the squint. Periodic and alternating squints do not give rise to fear of loss of sight, they may exist for years without the eyes suffering much. But if these varieties become constant, the danger of losing the sight of one eye is great for in the constant concomitant squint, the patient will not use this eye at all for central fixation, and its vision will soon be lost. He will only see indistinctly with a peripheral portion of the retina; his vision will become not only diminished, but also eccentric. If the good eye be closed and the patient is told to look at an object, he will not fix it with the centre of his eye corresponding to the macula, but turn his head and bring his eye in such a direction that the form of the image will reach that peripheral portion of the retina he is accustomed to use. If there is not central fixation, binocular vision is impossible, and even after an operation, though the cosmetic effect may be good, the patient will seldom be able to enjoy binocular vision again.

This want of central fixation produces what is called faulty projection in the squinting eye; the patient is not able to locate an object he is looking at correctly, and if told to touch it, he will not be able to do so, if the good eye is closed. In almost all cases where the squint has existed for some time, the sight of the squinting eye will suffer; the patient will soon learn to suppress the annoying diplopia, caused by the deviation of the squinting eye from the visual line, and this will result in a dullness of the retina and the sight will diminish gradually. It is on account of these dangers that an operation for squint is advisable, and it ought to be performed as early as possible. Complicated cases of squint, (paralysis or opacities of the cornea and lens) offer a less favorable prognosis. If the cause cannot be removed, the eye, after the operation, is apt to return sooner or later to its former position.

Treatment of Strabismus is either orthopedic or operative. The plan of tying nut-shells with perforated centres before the eyes, and forcing both eyes to look through the central opening, is very old, but of little value; the child will see only with one eye at a time. The same end is aimed at by the use of squint glasses, where one half is not transparent, or where only the centre of the glass is transparent. The best plan is to remove the cause and as this is generally hypermetropia, the correction of it by glasses offers the best remedy at our disposal. Periodic squint and alternating squint are often entirely relieved by the use of proper glasses; great care must be taken to have each eye corrected, if the difference between the two eyes is not too great; should the sight of one eye have suffered materially, the systematic exercise of it becomes necessary. This is best done by bandaging the good eye for one hour twice a day, correcting the hypermetropia by glasses, and forcing the patient to use the weak eye alone during this time. In the beginning this may cause more or less inconvenience, but soon the vision and accommodation of the eye will improve. It will be of great service in preserving the sight of the eye. This exercise should precede every operation for squint, where the sight of the eye has suffered much from non-use. Atropia to neutralize all efforts of accommodation may be of service in young children just beginning to squint, and it will facilitate the selection of glasses for such patients. Glasses may be used for children quite young. If they cannot read, the strength of the glasses has to be estimated by the ophthalmoscope. The operation for squint is undoubtedly the best remedy we have in our possession, but it should be only a part of the treatment; glasses and systematic exercise of the eyes, should be used long after the operation. The neglect of this plan has made the operation only partly successful in the hands of many surgeons. The operation for squint has been practiced since 1839, (Dieffenbach.) It consists in a division of the internal rectus for convergent, of the external rectus for divergent squint. Ether is to be given and the lids are to be held apart by means of a speculum, the conjunctiva is seized by means of a pair of fixation forceps over the muscle to be operated upon, about four mm. from the sclero-corneal margin; a vertical incision is made between the fixation and the cornea over the muscle to be divided, and by means of the blunt-pointed curved scissors, introduced into the wound, the subconjunctival tissue is loosened and the capsule of Tennon opened. A tenotomy hook is now introduced and kept close to the sclera; by making it sweep around the eyeball, the muscle is caught in it, and its insertion into the sclera exposed. This insertion of the rectus internus is about six mm. from the sclero-corneal junction, that of the externus eight mm.

By means of the blunt pointed curved scissors the tendon is divided close to the sclera. It is of great importance to have all the muscular fibres divided; the hook is introduced again beneath the conjunctiva and must pass readily up to the junction of the conjunctiva and cornea, below as well as above. After all fibres have been divided, pressure on the lids by means of a towel or sponge will check the bleeding, and prevent the very annoying subconjunctival hemorrhage to a great extent. After this the patient is aroused and told to fix a near object and move the eye in the direction of the divided muscle; if he can do this and still shows signs of squinting, search must be made for some fibres, that may have escaped division. The patient must not be able to move his eye in the direction of the divided muscle. A fine curved needle with black silk must be used to bring the conjunctival wound together, to prevent the formation of granulations and the sinking of the caruncle: one stitch only being necessary. The eye is now cleaned, all coagula removed and then bandaged. Linen smeared with Vaseline is put next to the lid, over this borated or absorbent cotton; this is retained in place by a flannel bandage. Cold water applications may be used, but if the operation is not done at the patient's house the use of the bandage is better. It may be left on until the next day. The eye is inspected and cleaned and the stitch may be removed on the following day. After this the correcting glasses must be used at once and if the effect is not very perfect, Atropia should be dropped into both eyes for a few days to prevent all accommodation and convergence. The glasses have to be worn for several months constantly; during this time the patient must frequently every day, exercise the rectus externus by closing the good eye and trying to look as far outwards as possible. Bandaging the good eye for an hour, night and morning should also be practised.

It is not always that we restore perfect binocular vision, but the cosmetic effect may be perfect. If however the squint operated upon is in a more recent state, as in young children, binocular vision is often restored. The effect on the sight of the eye operated on is often quite surprising, patients, that could hardly read before the operation, may be able to see much better immediately or a few days after the operation.

In the majority of cases however slight convergence will remain, or show itself soon after the operation. In this case a similar, compensatory operation must be performed on the corresponding muscle of the other eye. This should be done about two weeks after the first operation; but it may also be done at the same time with the first operation, if the squint is so marked that one operation can hardly be expected to relieve it; the second operation must generally be made very slight or too much of an effect is obtained.

If you are not sure that your patient will or if he cannot return for a compensatory operation on the fellow eye, and the squint is marked, it is best to operate on both eyes at the same time: this however is not without danger.

If the squint is of moderate degree, and an operation upon the other eye not consented to, the use of a counter-suture is of great help, as it will draw the eye entirely over to the opposite side and prevent the healing of the divided muscle near to its original insertion. Tying the eye out, we have to pass a strong thread of silk through a large fold of conjunctiva, which is picked up by the forceps near the outer margin of the cornea, this thread is fastened to the skin in the region of the temples under the hair, by passing it through the skin, thus rotating the eye entirely over to the outer canthus. The suture causes but little inconvenience to the patient and an operation which under ordinary circumstances will remedy a defect of 3 to 4 mm. will with this modification diminish the squint by 4 to 5 mm. The silk may be left in place for two days.

Another operation is that of Critchett. He opens the conjunctival sac and the capsule of Tenon, after fixing the eyeball, over the internal rectus, by means of a small horizontal incision corresponding to the lower edge of the tendon near its insertion. By introducing a strabismus hook the muscle is held, and is divided by means of scissors introduced into the capsule of Tenon. Care should be taken to see that all the muscular fibres are divided. No after treatment nor conjunctival suture is needed. This is the greatest advantage of the operation, but it demands greater skill than the first method.

Advancement of a muscle.—This becomes necessary if a muscle is extremely weak, in insufficiency or paretic conditions of a muscle or if a muscle has become attached too far back after an operation for squint. The object of the operation is to shorten the muscle and thus increase its power. (1.) The conjunctiva over the muscle is seized with the fixation forceps (2.) a vertical incision is made into the conjunctiva and the capsule of Tenon 3 mm. from the margin of the cornea (3.) the tendon is caught on a strabismus hook and a strong black silk thread is tied around the muscle, (4.) the tendon is now divided a short distance from its insertion and three sutures are passed through the muscle posterior to the ligature. (5.) The muscle is drawn forward and a piece of it, including the ligature is cut off, 2 or 5 mm. long according to the effect required. (6.) The muscle is sewed to the insertion by means of the sutures passed through it before. The conjunctiva is to be included in the sutures. A tenotomy of the opponent is now to be made in extreme cases. The suture uniting the shortened muscle to the scleral insertion, must be left in for four or five days. The patient ought to be kept perfectly quiet during this time and ice applications should be made during the first twenty-four hours.

On account of the connection of the sheath of the muscle with the capsule of Tenon, the retraction of the muscle can only take place to a small degree. Not more than four mm. can be corrected at one time. If the deviation amounts to more than this, say seven mm. two operations will be absolutely necessary, but the second one must not be made as freely as the first one, as only three mm. would remain to be rectified by the second operation. Squint of a higher degree than this may require even a third operation; the third operation is to be performed on the muscle that had been operated on first. Should the effect of an operation be too great, causing a slight deviation in the opposite direction, a strong suture including a good deal of conjunctiva and some subconjunctival tissues must be used to close the conjunctival wound. A slight amount of deviation in the opposite direction is not of much importance in tenotomy of the internal rectus, because the contraction of the scar, and the constant convergent efforts the eye has to make, may relieve this entirely.

Paralysis of the internal muscles of the eye may affect the sphincter or constrictor of the iris, causing mydriasis paralytica. As this muscle is supplied by the third nerve, this is frequently found to accompany paralytic affections of the other branches of the third nerve, but it alone may be affected, and is in these cases due to a lesion affecting the small root of the ciliary ganglion. It is often due in such cases to syphilitic lesions or is one of the sequelae of diphtheria. In traumatism it is probably due to a concussion of the nerve fibres, see Mydriasis.

Paralysis of the dilator of the pupil is due to lesions of the sympathetic or to spinal troubles. Its symptom is a very narrow pupil, myosis. It generally accompanies diseases of the spinal cord. See Myosis.

Both muscles may be paralyzed by pressure of the iris, this is called *Iridoplegia* and is generally caused in occlusion of the pupil, by the pressure of the accumulating aqueous humor in the posterior chamber, which cannot find an entrance into the anterior chamber on account of the adhesion of the iris to the lens. It is also caused by the pressure of a swelling lens on the iris and in diseases associated with great intraocular tension (Glaucoma.)

Paralysis of the ciliary muscle; Cycloplegia. Paralysis of accommodation. It is generally associated with paralysis of the sphincter of the iris, because both are supplied by the motor fibres of the ciliary ganglion, but it is in rare cases found alone, without mydriasis, and in such cases the paralysis or paresis of accommodation is generally one of the sequelæ of diptheria or typhoid fever.

In all these cases of paralysis of the internal muscles of the eye the galvanic current will be found beneficial. Those that are due to syphilis or are the sequelæ of constitutional diseases, such as diphtheria, offer the best prognosis. Tonics and constitutional remedies may therefore become necessary; mydriasis or paralysis of the sphincter of the iris and of the ciliary muscle will be temporarily relieved by the action of eserine. Myosis to a slight extent by the use of atropia. Strychnine will be of great service in some cases, it may be administered by the mouth or hypodermically.

Nystagmus is a peculiar oscillatory movement of the eyeball, entirely beyond the control of the patient, which becomes worse by excitement or accommodative efforts. It is generally associated with defective sight. It may be congenital, or it will develop in early infancy on account of maculæ corneæ, cataract or staphyloma, or is due to great errors of refraction. Later in life it may develop by great exertion of one muscle, especially if this was accompanied by an awkward position of the head, and by dim light, as is the case with miners.

The oscillation is usually in a horizontal direction, but sometime the eyeball will oscillate up and downwards and in rare cases it will make rotatory movements. Only one or both eyes may be affected. A cure of this trouble is very doubtful, as it depends on a weakened condition of the whole eye. An error of refraction, mostly hypermetropic astigmatism, if existing, ought to be corrected by glasses, and as one eye sometimes squints, a tenotomy in such a case will benefit the patient. Electricity will do good in cases caused by great exertion of one muscle or when the muscles are generally weak.

CHAPTER V.

THE CONJUNCTIVA.

THE conjunctiva is a mucous membrane, lining the inner side of the lids and covering the anterior portion of the eyeball. That part connecting the conjunctiva of the lid with that of the eye ball is called the fold of transmission or fornis. It forms a lower and upper cul-de-sac, called the retro-bulbar or palpebral folds. Near the inner canthus a small fold of it is reflected backwards, this is called the semilunar fold or membrana nictitans; it is of varying size, and is the rudiment of a third eye-lid. Still nearer to the inner canthus is a small rounded eminence, called the caruncula lachrymalis which is composed of modified skin, it contains many follicles and is covered with conjunctiva and has small hairs projecting from it in many cases.

The conjunctiva differs in anatomical arrangement somewhat in its different parts; it is composed of an epithelial, a papillary and a loose connective tissue layer. The epithelium of the conjunctiva is arranged in layers of cells; these are more or less conical in shape at the palpebral folds, but become flatter as they approach the cornea, or the free edge of the lid. The next layer, the papillary layer differs but little from the tissue below; it is formed by a network of fine connective tissue fibres and elastic fibrillæ; this layer is very thin near the cornea, becomes thicker towards the folds of transmission, and is very thin again near the free edge of the lid. The next layer called subconjunctival or episcleral connective tissue layer, is only found under the conjunctiva of the bulb and the folds of transmission; its meshes are very large, and exudation into it is of frequent occurrence. It is on account of this layer that the conjunctiva of the eyeball is so freely movable and can be lifted up with such ease.

The blood-vessels of the conjunctiva are derived from the external carotid, through the branches of the transverse facial and of the external maxillary artery; the blood supply from this source reaches the eye at the outer canthus; from the internal carotid through the branches of the anterior ciliary arteries. Free anastomosis takes place between the different branches. Most of the venous blood is carried off by the facial and some by the ophthalmic vein. The vessels are usually not very conspicuous, but they become easily engorged on account of the looseness of the surrounding tissue, and are then plainly seen. The nerves are derived from the ophthalmic division of the fifth nerve, and terminate in great abundance near the free edge of the lid, which on this account is much more sensitive than the conjunctiva of the eyeball or the fold of transmission. A small foreign body lodged near the free edge of the lid will cause great pain; in the lower fold of transmission, it may remain for many days without causing much irritation.

The lymphatics of the conjunctiva form a net-work, which is especially dense at the corneal margin, they are in direct communication with the scleral and corneal canals.

The conjunctival glands are numerous, their secretion is of greater service in moistening the eye, than the tears; extensive changes of the conjunctiva are therefore apt to leave the conjunctiva perfectly dry, a condition called Xerophthalmus. The removal of the lachrymal gland causes hardly any changes in the moisture of the eye. The conjunctiva is continuous with the mucous membrane of the nose, by the lining membrane of the lachrymal canals and extends to the lachrymal gland through the small ducts of the gland. The conjunctiva does not end at the cornea, its outer layer extends some distance over the periphery of the cornea; this is called the Limbus conjunctivae. The most superficial layer of the epethelial cells extends even over the entire surface of the cornea. The limbus differs slightly from the rest of the conjunctiva, because its fibres are radiating and dense.

The subconjunctival tissue may become distended by serum, chemosis; or by blood, ecchymoma; or by air, emphysema.

Chemosis.— Exudation of serous fluid into the subconjunctival tissue occurs frequently, it is called Chemosis; the conjunctiva looks, in this state, like a transparent bag filled with fluid. It may develop very rapidly, sometimes with the slightest lesions of the conjunctiva, and it may at times assume such proportions, that it projects through the palpebral fissure. This exudation becomes in some forms of conjunctival inflammation the source of great danger to the eye, as by its pressure on the anterior ciliary vessels, it may interfere with their circulation so that the nutrition of the cornea is greatly impaired, which may even lead to a breaking down of it. This is especially the case when the lids are heavy and drawn tightly over the eye on account of inflammatory changes. Chemosis is of frequent occurrence in old people on account of the lax condition of the conjunctiva, and in some forms of orbital disease, when the return circulation is interfered with, it becomes a very prominent symptom.

Treatment.—In simple, uncomplicated cases of chemosis gentle pressure, by means of a pressure bandage, will hasten the absorption and disappearance of the exudation. In inflammatory conditions free scarifications by means of a scalpel are needed.

Ecchymoma subconjunctivalis (Fig. vii.) is the extravasation of blood into the subconjunctival tissue. In operations on the eye and especially on the muscles of the eye, this is very apt to occur. It may be caused by wounds or injuries of the conjunctiva, but is also frequently found as a symptom of fractures of the base of the skull, especially if implicating the orbital walls. In these cases the ecchymosis of the conjunctiva is apt to occur first in the upper or lower portion of the conjunctiva, according to the seat of the injury; and it will extend also to the lids. It is also caused by a rupture of small subconjunctival bloodvessels; it may be due to severe straining, coughing or sneezing; sometimes it will occur without any apparent cause. In most of these cases the ecchymosis is found under the conjunctiva of the eyeball and extending up to the corneal margin; it is generally quite flat, but it may appear like a red flattened elevation. Very small extravasations of blood accompany imflammatory affections of the conjunctiva; they occur frequently in catarrhal conjunctivitis. The extravasated blood will gradually disappear. To hasten it, a mixture of tincture of arnica and water, or applications of hot water for five or ten minutes at a time may be ordered.

Emphysema of the conjunctival tissue is found after injuries of the conjunctiva or the orbit, or after operations on the lachrymal apparatus, and it may extend in rare cases even to the orbital tissue. It presents a colorless swelling which has the peculiar crackling sensation of an emphysematous condition. It is relieved by pressure; this will also prevent the entrance of more air, and hasten the absorption of the extravasated air.

Inflammatory conditions of the conjunctiva may affect only a part of it, as in phlyctenular and some cases of traumatic inflammation, but generally the whole of the membrane participates in the process. The main features of an inflammatory attack are hyperaemia; this is followed by more or less abundant serous exudation, which forces its way through the epithelial layer. The secretion of the glands and follicles is also increased and the discharge becomes more or less thickened by the presence of mucus; the irritation is also transmitted to the lachrymal gland and an increased flow of tears follows; later migration of white blood corpuscles may take place. If the process stops here, we have an inflammatory action, accompanied by an engorged state of the vessels, by an exudation of albuminoid fluid which is mixed with epithelial cells, mucus and tear fluid and may contain some pus corpuscles. This is the essential character of a *catarrhal inflammation.*

If the process extends deeper and becomes more intense, the hyperaemic condition affects also the deeper vessels; this is followed by chemosis and proliferation of the connective tissue cells, with free escape of white blood corpuscles, resulting in hyperplasia of the subconjunctival and papillary layers of the conjunctiva and the formation of pus; the secretion is now more purulent in its character. These are the features of a *blennorrhoeic* process; if this process is acute, the formation of pus is the principal feature, if it is chronic, the hypertrophy of the deeper, especially of the papillary layer is the principal lesion, as in *granulated lids.* In severer cases the exudation becomes more plastic, fibrinous in character, and is deposited on the conjunctiva in the shape of a membrane, which may form on the free surface of the conjunctiva, especially that of the lids, as in *croupous* inflammation; or it may invade the whole thickness of the lids as well as the surface of the conjunctiva, this is the case in *diphtheritic conjunctivitis.*

Hyperaemia of the conjunctiva is often the beginning of an inflammatory process, but very often it is merely the result of an irritation. Simple hyperaemia of the conjunctiva is not accompanied by any inflammatory products; there is no discharge, except an increase of the tear-fluid, which is caused by a reflex irritation of the sensitive nerve fibres. The irritation may be of a mechanical character, it may be caused by the presence of foreign bodies or by inverted or loosened eyelashes, by impurities of the air, as we have it occur frequently in crowded rooms, or if the air becomes loaded with irritating chemical vapors. Sharp, cold air and bright lights, especially bright artificial light, and tobacco smoke, particularly that of cigarettes will produce it also. Another cause of it is forced accommodation, especially in artificial light; this produces hyperaemia of the muscular arteries and as the blood supply of the conjunctiva is also derived from these vessels, the hyperaemia will extend to the conjunctival vessels. This variety of hyperaemia is very obstinate in regard to treatment, especially if the forced accommodation is necessitated by an error of refraction, such as hypermetropia or the different varieties of astigmatism, because the cause remains constantly at work. The trouble manifests itself by an unusual redness of the conjunctiva, especially of the lids. The engorged vessels will cause the sensation of roughness, as if a grain of sand had got into the eye: this is accompanied by a dry and hot feeling of the lids, lachrymation to a moderate extent, and an itchy sensation, which may prove very annoying.

The *treatment* of the affection must include the removal of the cause in the first place. The selection and the use of proper glasses in cases of errors of refraction is absolutely necessary. Temporary relief is obtained by the use of cold water applications in the shape of compresses or if possible in the shape of an eye-douche. An eye-douche may be improvised by attaching a soft rubber tube to the water supply of the room. A perforated flat piece of tin, of the size of a dime, is now fastened to the other end of the tube, and the water is allowed to flow against the closed eyelids with moderate force. A fountain syringe, or a soft rubber eye syringe will answer the same purpose. The douche should be applied twice a day for about ten minutes at a time.

Very mild astringent lotions are also of great help. ℞. Sodæ biboratis, gr. x; aquæ foeniculi, ℥iv. S.—To be applied twice a day; bathe the closed eyelids with it, and allow one drop to get into the eye, or ℞. Zinci sulphatis, gr. ij; aquæ rosæ, ℥iij. S: eye lotion; or ℞. Acidi boracici, gr. v; aquæ camph, ℥ij. D.—These are to be used like the first lotion. If the patient complains especially about a dry burning sensation of the eyes, which is often caused by errors of refraction, the following aromatic eye spirits, composed of spirits of lavender and spirits of rosemary, will prove of great benefit. It is to be applied to the closed lids twice or three times a day, by means of the fingers or a piece of fine linen, and the vapor of a few drops of it, produced by rubbing a small quantity of it between the hands, may be allowed to get into the eye.

The different inflammatory affections of the conjunctiva are (*a*) general; of these we have (1) *Simple* or *catarrhal conjunctivitis*, (2) *Purulent ophthalmia*, (3) *Blennorrhœa neonatorum*, (4) *Gonorrhœal ophthalmia*, (5) *Croupous conjunctivitis*, (6) *Diphtheritic conjunctivitis*, (7) *Chronic blennorrhœic conjunctivitis or granular lids*, (8) *Follicular conjunctivitis* (*b*) *localized*, (9) *Traumatic and* (10) *Phlyctenular conjunctivitis*.

Simple catarrhal inflammation of the conjunctiva (Fig. viii), is of frequent occurrence. It may come on as an acute attack and last as such for several weeks, with more or less severe symptoms, or it may be chronic; this variety may last for many months and even years, causing but little inconvenience. The conjunctiva becomes red, the engorged vessels can be distinctly seen; exudation takes place with loss of epithelial cells, and swelling of the papillary layer.

The secretion is changed; it is more copious, contains mucus, epithelial cells and later also pus corpuscles. The lighter forms of the disease are limited to the fold of transmission and the tarsal conjunctiva. The ocular conjunctiva may at other times be the principal seat of the lesion, which causes a bright pink appearance of the eyeball; this is called "pink eye." In the severer cases the whole conjunctiva suffers, and there is swelling of the deeper layers, especially of the fold of transmission with marked chemosis and swelling of the lids. (Schwellung's Catarrh) *Catarrhal ophthalmia.* Such severe cases are associated with a febrile condition of the patient and redness and local heat of the lids. The discharge becomes somewhat purulent and small whitish plaques of exudation may be seen on the conjunctiva mostly near the corneal margin; sometimes the disease is associated with a pustular deposit resembling a phlyctenular process; even the cornea is apt to be implicated. The principal objective symptoms are—1. Marked hyperæmia, especially at the fold of transmission, causing redness of the transparent conjunctiva; but the meibomian glands can be seen through the conjunctiva on everting the lids and the single vessels can be made out distinctly. 2. Small hæmorrhages from the engorged vessels are of frequent occurrence and are very characteristic of a catarrhal inflammation; they occur especially on the ocular conjunctiva. 3. The loss of epithelial cells and the swelling of the papillary layer are not so extensive as to change the smooth appearance of the conjunctiva except in chronic cases, where the conjunctiva looks as if fine sand had been sprinkled over it. These conditions are most marked at the fold of transmission which appears bluish-red and is swollen. 4. The discharge is viscid and contains many cells, which form with the albuminoid matter little lumps; 5, it cannot be all carried off by the canaliculi, and it will flow over the cheek, causing redness and excoriation of the edge of the lid; 6, during the night it will evaporate and the edges of the lids are glued together in the morning. 7. Fissures of the lids, especially at the external canthus are formed sometimes; these are very painful when the lid is turned or the eye opened; 8, they may give rise to severe blepharospasm and this may lead, if the skin of the lids is lax, to an entropium.

The subjective symptoms are: 1. A rough feeling, as if a foreign body had got into the eye, but the sensation will not change when the eye is moved and is especially felt under the upper lid. 2. The patient complains about the lids being stuck together in the morning, which is due to the evaporation of the discharge gluing the eyelashes together. 3. Light, and especially artificial light, is very troublesome, and, 4, this causes an increase of the symptoms at nights. 5. The lids become easily excoriated by the overflow of the discharge, and are very itchy. 6. Eczematous patches may be found to complicate the troubles, especially in children. 7. The patient also complains of dimness of vision; this is not due to an impairment of sight, but it is caused by small flakes of thin mucus, which will get over the cornea, and produce the sensation as if a fog was spreading over the patient's eye. This may be alarming to the patient, but by rubbing the eye, the mucus is easily removed from the cornea, and the patient sees as well as before. 8. Bright lights are irritating, but there is not great dread of light (photophobia).

Causes of Conjunctivitis; these are manifold. It may be an idiopathic affection caused by exposure to cold and wet, by wind and bad air, both vitiated with foul exhalations or irritating dust and chemicals, and to sudden changes of temperature. It is therefore more frequent at certain seasons of the year when the atmosphere is moist and chilly or when sudden changes from hot to cool or from cold to warm weather take place; it is frequently caused by contagion. It will not only spread from one eye of the patient to the other, but by carelessness the discharge may come in contact with the eyes of other persons, and thus it will spread, especially in armies or asylums, very rapidly. It may be consecutive to the irritation caused by foreign bodies in the eye, or it may spread from the inflamed lids, Blepharadenitis, or from an inflamed tear-sac to the eye. Catarrhal troubles of the Schneiderian membrane are very apt to reach the eye, and set up a conjunctivitis which is very apt to be found especially near the canthi of the eye, the so-called conjunctivitis angularis. Acute deep inflammation of the eyeball or orbit are very apt to set up conjunctival troubles. Iritis or keratitis are very apt to be accompanied by more or less conjunctivitis.

The disease is also frequently found with the eruptive fevers, measles, scarlatina, and small pox. A chronic variety appears often in old people, without apparent cause, and is extremely obstinate to treatment; the same may be said of that kind which accompanies alcoholism, especially if the cause of it is not removed.

The differential diagnosis between catarrhal conjunctivitis and other diseases of the eye is sometimes quite difficult. Conjunctivitis might be taken for blepharadenitis on account of the crusts found on the lashes. In conjunctivitis the skin, after removal of the crusts, is not changed; in blepharadenitis this is always the case. Keratitis is easily differentiated from conjunctivitis on account of the impaired transparency of the cornea and the peculiar ciliary injection surrounding the cornea. Iritis is very often taken for a severe conjunctivitis, but in it we have severe pains in the eye, as well as along the distribution of the 5th nerve; we have an immovable pupil and especially impairment of vision; this and the striking ciliary injection will make it easy to differentiate it from conjunctivitis.

Treatment.—The disease may be so mild and it may accompany diseases so serious, that it hardly requires any special treatment, like that in measles or scarlatina. Other forms will do well by removing the cause. Placing the patient under the best hygienic condition, plenty of fresh air, good substantial food, and the avoidance of irritating beverages like beer or liquor and of tobacco-smoke, will cause the disease to disappear in a short time. Even a number of acute cases will get well without any treatment, but there is always great danger of the disease becoming chronic if not immediately attended to.

The principal remedies in catarrhal inflammation are astringents, and of these the nitrate of silver in acute cases is the most reliable. In cases with great local heat, swelling, and copious discharge, a solution of five grains of nitrate of silver to an ounce of water should be used by means of a brush, once every day. The lids should be thoroughly everted and the application should be made to the fold of transmission. After the application the parts must be washed off, first with a very weak solution of salt, and after this with pure water. Often cold compresses have to be applied; pieces of cloth, cooled on ice, should be placed on the closed lids, and removed every few minutes during the day—in less severe cases for one hour three or four times a day. The eyes should be kept very clean, and before retiring the edges of the lids should be anointed with simple cerate or sweet oil or cold cream. This is advisable in all cases of conjunctival inflammation in which the lids are glued together in the morning. It prevents also the discharge from coming in contact with the edge of the lids, causing redness and even inflammation of the parts. There is more or less fever in these cases; the patient should be kept in the house and a mild cathartic administered. If there is great tension of the lids with severe injection, two or three leeches should be placed near the outer canthus. There is sometimes slight ciliary neuralgia; this is relieved by a few drops of a mild solution of atropine—but the atropine must not be continued, as it might irritate the conjunctiva too much.

In milder cases a weak astringent is called for, and one of the best remedies is alum. The alum used for eye lotions must always be potash alum, because it is less irritating and purer than the commercial ammonia alum; ʒiv of alum to a pint of water makes an excellent lotion, this is five grains to one ounce of water. Instead of the plain water, fennel, camphor, or rose-water may be used. The edges of the lids should be washed with this preparation, and a few drops must be put into the eye each time it is used. Other astringents can be used instead of the alum; if the discharge is thick, mucous, and abundant, a solution of boracic acid five grains to one ounce of fennel water acts very nicely. In more chronic cases a solution of two grains of sulphate of zinc to one ounce of rose-water does good service; or the solution of the biborate of soda, five grains to one ounce of camphor water.

In obstinate, chronic cases, the collyrium stringens luteum in its pure state or mixed with equal parts of water has given good results. A few drops of it must be dropped into the eye mornings and evenings. In cases where there is great irritation in the free edges of the lids, these astringents should be used in combination with mucilage of quince seeds. ℞. Sodæ biboratis, gr x; aq. camph. ʒij; mucilag. cydonior. et aqu laurocerasi āā ℥ss. D. S.—Use as an eye lotion three times a day (Derby). If blepharadenitis complicates the case, this last lotion and the following salve can be recommended. ℞. Hydr. oxyd. rubri, gr. ij; liq. plumbi subacet. gtts v; ungt. simpl. ʒij; M. f. ungt. S.—Apply on going to bed to edge of lid. Of all astringents that are recommended for eye lotions to be dropped into the eye by the patient, the nitrate of silver and the sulphate of copper should not be used on account of their harsh irritating properties; nor the acetate of lead on account of the danger of having it deposited, in slight abrasions or ulceration of the cornea, as white lead opacities, which might greatly impair the patient's vision. Of the greatest value are local applications of astringents, made directly to the fold of transmission by the physician; of these mild solutions of nitrate of silver have been mentioned; if the sulphate of copper is used, it has to be done quite gently and the surplus of it removed, by washing it off with water carefully. Alum may be used more freely, as often as once every day. The sulphate of copper is only to be used in chronic cases, where there is great swelling or hypertrophy of the papillary layer. As the light is very troublesome to the patient, blue or smoke-colored glasses should be used; these glasses must be large and curved. Coquilles.

(2.) *Purulent Conjunctivitis, Purulent Ophthalmia; Acute Blennorrhœa* (Fig. ix.).—This is a grave affection of the conjunctiva, not only on account of the lesions of the conjunctiva which it may produce, but on account of the serious complications of the neighboring portions of the eye. The affection does not only affect the epithelial and papillary layers, but extends to the deeper subconjunctival tissue. The injection is intense, extending early to the ocular conjunctiva; the meibomian glands or single vessels cannot be seen. The whole surface appears bright scarlet, and is very rough on account of the breaking down of the epithelial layer and the swelling of the papillary layer.

Hypertrophy of and effusions into the deeper layer cause chemosis and œdema of the lids; they are red, tense, and hot, feel soft and doughy; especially the upper lid becomes very heavy, and hangs down over the margin of the lower lid, so that the patient is not able to open the eye for days. The discharge is thick, creamy, and is often retained in the eye by the heavy upper lid, and acting as a foreign body, will increase the irritation. On lifting the lid, a large quantity of the discharge will flow out. It is very contagious and great care must be taken to prevent it from infecting the other eye; the patient must have his head inclined to the side of the diseased eye, to prevent the discharge from flowing over the nose. In acute cases the principal feature is the copious, thick discharge composed almost entirely of pus and mucus and the great injection of all the conjunctival vessels. Chemosis is likewise one of the main features; it may overlap the margin of the cornea. This and the pressure of the heavy upper lid becomes one of the greatest dangers of the disease; the compression of the ciliary vessels will not only affect the ciliary veins, but also the arteries, and the nutrition of the cornea will be disturbed; this will not cause any serious consequences if it is not continued a long time; then the cornea will break down and large ulcerations will be formed. These ulcers begin generally at the margin, but will spread rapidly all over the cornea, and may destroy it altogether. At other times slight infiltration may make the cornea appear hazy, but on the early abatement of the symptoms, this will become absorbed and the cornea restored to its former state, but this may also lead to ulceration. In chronic cases the hypertrophy of the tissues and formation of granulations is the main feature. As the disease advances, the epithelial layer will be almost entirely lost, the papillary layer becomes more irregular and in the subconjunctival tissue contractions will take place, that will often lead to great change of the shape of the lids, causing them to turn inwards. (Entropium). Or the conjunctiva of the lid may swell to such an extent that the lid becomes entirely everted. (Ectropium.) —The puncta are removed from the tear fluid by the swollen conjunctiva, the tears cannot pass off and have to run over the lid, causing excoriations of the margin of the lid. The raw edges of the lids may lie in close apposition for days and may grow together, *anchyloblepharon*.

The duration of the disease may vary from a few weeks to many months. In most cases the infiltration will progress rapidly, reaching its full height in twelve to twenty-four hours; at the utmost in two or three days.

The principal symptoms are (1) great and uniform redness of the whole conjunctiva, (2) chemosis and œdema of the lids; (3) great thickening and roughness of the fold of transmission. (4.) The discharge is purulent and copious, sometimes covering the lids so as to give them a gray appearance. (5.) The pain in the eye is quite severe, caused by distension of the conjunctiva and pressure of the engorged tissues.

According to the causes we have several varieties of the disease to deal with. Though the main features are the same as just now described, they differ from each other in many respects. The simple purulent ophthalmia may be an idiopathic affection, and favored by a low state of the system, it may become especially dangerous if affecting people who are ill-fed or broken down, and are crowded together in asylums or hospitals; or it may be due to a chronic form of conjunctivitis freshly irritated; or it is caused by infection with the purulent discharge of another eye. This discharge is very poisonous, and the greatest care should be taken in dressing such an eye, not to carry the poison on our fingers to the eyes of the next patient or to our own eyes. The poison starting the inflammatory action may have been taken from a leucorrhœal discharge of the vagina.

If pregnant women suffer from leucorrhœa, the eyes of the new-born baby are in great danger as the head passes through the vagina. If thus produced, the disease is called (3) blennorrhœa neonatorum. Again, the poison may come from a gonorrhœal discharge; this is one of the most terrible of all poisons to the conjunctiva. It is very violent and many eyes are lost by the inflammation it sets up; this is called (4) gonorrhœal ophthalmia.

Differential diagnosis.—The clinical features of the three varieties of the disease are so much alike, that it will be difficult to tell them apart, if we cannot find out the source of infection. If the disease occurs in new-born children that have not been exposed to injurious influences, and where the disease makes its appearance within a few days after birth, the diagnosis is plain; if it occurs perhaps only one or two weeks after birth, we must assume that the poison produced a slight inflammatory attack, that was overlooked, and that some exciting cause, a slight exposure, uncleanliness or improper or insufficient food brought on an acute attack. Sometimes we are called upon to treat children where the disease showed itself several weeks, perhaps as many as four weeks after birth. In many of these cases I have found out that the same basin, towel, or sponge which had been used to remove the lochial discharge of the mother, had also been used for the child. Infections with the discharge of the vagina may take place therefore weeks after confinement.

If the disease occurs very suddenly in a young man and assumes rapidly a violent and threatening aspect, we would naturally look for gonorrhœal poison. The infection may have been noticed at the time it happened, but in most cases it occurs without the patient's knowledge of it—perhaps he does not know the dangerous nature of the discharge. He may have used a cloth or handkerchief, soiled with the discharge, for his eyes, or he may have carried the poison to his eye on his finger. In such cases generally one eye becomes affected first, as early as six or twenty-four hours after infection, and the disease reaches within twenty-four hours a very high inflammatory state.

In other cases, where no source of this kind exists, we may have the history of sore eyes in the family or among friends; or it may appear after exposure; we shall have to look upon this trouble as a purulent ophthalmia. Other severe inflammatory actions of the eye might be mistaken for it, such as severe catarrhal inflammation. In this disease the injection may be marked, but single vessels and small hemorrhages can generally be found, and the meibomian glands are generally visible; this is not the case in blennorrhœa; we have here a uniform redness. The conjunctiva is perhaps uneven from small granular elevations in catarrhal affections; in blennorrhœa the conjunctiva is very rough and irregular, presenting clefts which bleed easily. The chemosis which we meet with in some cases of catarrh is bluish, transparent; the overlying vessels are not markedly injected; in blennorrhœa the swelling is red, tense, fleshy, and will overlap the corneal margin and sometimes the entire cornea. In catarrhal conjunctivitis the discharge is viscid, flocculent; in blennorrhœa it is thick, creamy, white or yellow. There are, however, cases where the two diseases seem to meet, and neglected catarrhal inflammation may become purulent at any time. Orbital diseases, especially cellulitis, may be accompanied with conjunctival congestion, chemosis and œdematous lids, but there is very seldom any discharge to speak of; it is slower to develop, the pain is much greater and the exophthalmus very marked.

Iritis is hardly ever accompanied by a conjunctival discharge, and the pain is of a different nature. Panophthalmitis may have likewise great and marked chemosis and swelling of the lids accompanying it, and there may be even a copious purulent discharge in the later stages, but this discharge is derived from an opening in the eyeball; the pus can be discovered in the interior of the eye before the cornea is affected, and the eyeball itself is much enlarged and is the principal seat of the disease; the lids are not so much affected.

Treatment.—The principal feature in the treatment of blennorrhœic processes must be great cleanliness; the secretion itself is a source of irritation to the eye, and a source of great danger to the other eye; it must be removed as often and as thoroughly as possible, and the eye must be thoroughly disinfected. In the beginning an antiphlogistic treatment, such as leeches, and cold, especially the latter, is absolutely necessary; later, powerful astringents are called for. The usual hygienic conditions must not be neglected. Of the greatest importance is the isolation of such patients if they are apt to come in contact with many people who are in a similar state of health and live in the same manner as the patient does. This is especially the case in the nurseries of our lying-in asylums, and our orphan asylums, barracks, and prisons. Patients with blennorrhœic trouble should not be allowed to sleep in the same apartment with the other inmates of such institutions; they should not visit the same schools, dining-room, workshops or play-grounds; they should be entirely separated from the rest of the inmates, having even a separate part of the building set aside for them, if there are many of them afflicted. Their clothing even, especially towels and handkerchiefs, ought to be kept apart from the rest of the wash. Of the greatest danger in such cases, is the dangerous habit of having one large towel for a number of people; infection by means of such an arrangement may be so rapid, that the disease spreads to a hundred or more persons in a single day, destroying the future of many persons; for in such cases, where the disease becomes epidemic in such an institution, it is usually marked by great violence of its symptoms and may destroy many eyes. Give, therefore, each patient a separate basin, towel, handkerchief, and even a separate brush and sponge for applying remedies with and for the removal of the secretion. The same precautions should be used in chronic blennorrhœic processes and granulated lids.

The cold applications should be made according to the direction given in the treatment of severe catarrhal inflammations. It is important that this should commence as early as possible, in fact during the very first stages this is the only application advisable. It must be kept up night and day, and be renewed at first every minute, later every two or three minutes. In the later stage of the disease longer intervals between the cold applications are necessary, especially if there are extensive ulcerations of the cornea. In these cases hot water fomentations may be advisable, say twice or three times a day for half an hour each time. This is necessary in order to stimulate the circulation and hasten the process of repair. Cold applications may be used in the intervening time. The discharge must be removed carefully every ten or fifteen minutes by allowing a stream of water or of a mild solution of boracic acid, half a drachm of it to a pint of water, or of a carbolic acid wash, fifteen drops to a pint of water, to run between the opened lids. The wash may be used by means of a syringe or a sponge. Great care must of course be used to keep the other eye from becoming inoculated with the discharge. Leeches are only called for in robust, strong people, where swelling of the conjunctiva or of the lids with great local heat are prominent features. If in such cases the upper lid is very thick and tense and difficult to evert, and the ocular conjunctiva densely infiltrated, so that there is much danger to the cornea, a canthoplasty ought to be resorted to. The loss of blood accompanying this operation is greater and has a more direct effect on the inflammatory action than the application of leeches; it will enable us to evert the upper lid freely, so that we can make the applications directly to the fold of transmission, and it will relieve the cornea from the pressure of the heavy lid stretched tightly over it. The operation itself is simple and requires only few instruments. The lids are held apart by means of a wire eye-speculum, which will put the outer canthus thoroughly on the stretch; a pair of straight scissors or a scalpel pushed under the canthus will now readily divide it up to the margin of the orbit. The skin of both the upper and lower lids is now lifted up by means of a pair of forceps and the canthal ligaments divided with scissors, introduced between the skin and conjunctiva. This ligament is easily exposed and felt as a tense band, by traction of the forceps, holding the skin. After a division of the two ligaments, we have to wait until the hemorrhage, which is generally quite profuse, ceases; the conjunctiva of the central portion of the wound is now seized and carried to the outer portion of the incision and fastened there by a suture of black silk; the upper portion of the conjunctiva is then stitched to the upper edge of the incision and the lower portion to the lower line of the wound. This can be done most conveniently after everting both lids, which manœuvre will tell us at the same time, whether the ligaments have been thoroughly divided, and thus secures the success of the operation.

In the first stages of the disease, the stage of hyperæmia and stasis, marked by tense infiltration and but very little discharge, only cold applications and no astringents are needed; as soon however, as the discharge becomes freer and more purulent, the use of the nitrate of silver becomes necessary. The application of a five-grain solution is in most cases sufficient; by applying it freely and leaving it in contact with the conjunctiva a short time before washing it off, we can produce a very decided effect, making the use of stronger astringents unnecessary; it may have to be applied in bad cases even twice a day. In milder cases it must be washed off and neutralized at once by a mild solution of common salt; one application a day is generally sufficient.

Milder astringents may be advisable in feeble subjects: a solution of tannin in glycerine, ten grains to one ounce of glycerine, may be instilled into the eye every two or three hours. But even in these cases washing the conjunctival sac every half hour with carbolic acid water must not be neglected if there is a copious discharge. If there is much pain in the eye, atropia should be used sparingly to relieve this; but if the cornea becomes affected, which in the beginning may assume the appearance of a delicate haze, spreading over a part or the whole of the cornea, or if the cornea has a peculiarly shining appearance, which is due to a loosening of the most superficial layer of the epithelial cells of the cornea, atropia must be used more regularly and freely, say one drop of a two-grain solution every two hours. If there are deep ulcerations of the cornea, especially near the margin, atropia must not be used, but eserine, two or four grains to one ounce of water, should be applied instead of it, one drop every three or four hours, in order to produce complete contraction of the pupil, which will prevent a prolapse of the iris in case perforation should take place. Should the ulceration, however, be central, the use of atropia is indicated for the same reason, as it draws the iris away from the perforation, if this should occur. If in such cases the anterior chamber becomes filled with pus, hypopion, a paracentesis, or a free division of the cornea may be necessary, see Keratitis suppurativa.

After the most acute symptoms have subsided, the cold applications must be used at longer intervals; the nitrate of silver in a five-grain solution, or instead of it the sulphate of copper, must be used very carefully, and only once a day or every second day. Later on, if the discharge is very small, or has entirely ceased, cold may be discontinued and only an astringent applied every other day.

Corneal complications may even require the use of warm compresses now in order to hasten the absorption of opaque exudative material. Should, after perforation, a bulging of the cornea be threatened, the use of a two-grain solution of eserine, morning and evening, together with the use of a pressure bandage firmly applied, will often prevent the formation of a staphyloma of the cornea. A bandage can, however, only be used when there is little or no discharge from the conjunctival surface. A pressure bandage is also of great service after the formation of an ectropium; by careful reposition of the lid and a carefully adjusted bandage, the ectropium will disappear in a short time, provided it is of recent origin.

(3.) *Blennorrhœa neonatorum.*—This is a disease of early infancy, and is often noticed a day or two after birth, or even later, if it be caused by the discharge of the vagina coming into contact with the eye of the child at the time of its birth; but cases may be brought to us with the history, that for several weeks after birth, the eyes were perfectly healthy. In such cases the cause of the trouble may have been at work very slowly, or the infection may have been caused by carelessness in the use of the sponge, towel, or basin, which had previously been used for removal of the lochial discharge of the mother.

The disease is more acute, as a rule, the sooner it shows after birth. Exposure to light or draughts is often given as the cause of the trouble, but careful inquiry will generally establish the fact of an existence of leucorrhœal discharge of the mother and a probable infection. The treatment of blennorrhœa neonatorum hardly differs from the rules given for the treatment of purulent ophthalmia. It is not necessary to use a stronger application than a five-grain solution of nitrate of silver once every day; this should be very carefully washed off with a solution of salt and clean water, as the albuminate of silver, which may be formed by the silver and the mucus, forms hard shreds, which must necessarily be very disagreeable and even painful, if they are allowed to remain in the eye.

Atropia must not be used unless the cornea shows signs of becoming affected. It is, therefore, necessary to inspect the cornea every day, as it may become affected early in apparently light cases. Sometimes it will be found difficult to expose the cornea on account of great swelling of the lids; a lid retractor, devised for this purpose, must be used in such cases. By introducing these lid retractors under the lids, they can be drawn upwards or downwards, leaving the cornea exposed, and free for inspection. The greatest care should be given to the application of cold and the use of disinfectants. Corneal complications are frequently met with in these affections because the disease is not early enough recognized or has been neglected by the nurse; it is often supposed to be only the effect of a slight cold, or to be due to exposure to the light, and is treated with breast-milk. During this treatment the cornea may become affected to such a degree that the eye is forever lost. A great number of the inmates of our blind asylums have lost their sight through blennorrhœa neonatorum. Nearly twenty-five per cent. of all eyes suffering from blennorrhœa neonatorum show corneal complications at the time of their first visit to our clinics, and a great number of these eyes it is impossible to save from total destruction.

(4.) *Gonorrhœal ophthalmia* is even a more pernicious inflammation of the conjunctiva. The source of this poison is pus from an inflamed urethra. The poison is so violent that it will set up a very serious inflammation in twelve or twenty-four hours. The poison may be carried to the eye in various ways. Frequently it is carried there by the hand of the patient, after dressing the parts. The patient may suppose a cold to be the cause of the inflammation, often denying an existing gonorrhœal discharge.

Another form of gonorrhœal ophthalmia is sometimes met with that accompanies metastatic affections of the sclera or iris, which have the same relation to gonorrhœa that rheumatism has to it. It is generally during the last stages of a gonorrhœal discharge, or even after its disappearance, that the disease attacks the patient. The first variety caused by infection is far more dangerous.

The treatment of gonorrhœal ophthalmia is the same as that of blennorrhœa neonatorum. The first step must be the perfect closure of the good eye, in case this does not show any inflammatory symptoms. The best plan of doing this, is to place a piece of borated linen over the closed lids, fastening it all around by means of collodium, and place over this a layer of borated cotton, and on top of this several layers of fine linen, the edges of which should be each separately fastened to the skin of the forehead, nose, and cheek by means of collodium. After this leeches may be ordered at once, to be applied to the temples in case of great pain and great swelling, and if this does not give prompt relief, especially if there is much chemosis, simply slitting the outer canthus will do much good. Ice applications must be made early, and continued the entire night and day, and if there is any danger to the cornea, canthoplasty should be resorted to at once. As the corneal complications will make their appearance very early, sometimes within twenty-four hours from the attack, atropia may be used from the beginning in very severe cases. The disease will last from four to eight weeks.

(5.) *Croupous or Membranous Conjunctivitis.* — This disease does not differ materially from purulent ophthalmia. It is a severe form of it, complicated by the formation of a fibrous exudation in the shape of a membrane on the surface of the conjunctiva. This is a variety we sometimes meet with in children of a strumous condition, whose state of health has been reduced by long-continued sickness, such as bad cases of measles, or especially whooping cough or by malnutrition. The child looks pale, bloated; it is often covered with eczematous patches, and is drowsy and easily irritated. The eyelids are swollen, and on opening the lids we find them to be heavy and densely infiltrated. If we succeed in everting the lids, which is a difficult task, we find the conjunctiva easily bleeding and covered with a grayish-white thin membrane, which can be removed by rubbing it with a piece of linen, or by means of a pair of forceps, leaving a red, easily bleeding surface of the conjunctiva exposed. At the next visit of the patient, the membrane will have formed again; it may sometimes form only in small patches. The discharge is similar to that of a simple purulent ophthalmia, the chemosis is very marked and the danger of corneal complications, though great, is not so great as in diphtheritic ophthalmia.

The treatment must be like that of a severe catarrhal inflammation, but antiphlogistic remedies such as leeches or cathartics are seldom called for, as the patients are generally reduced in health.

Ice applications and great cleanliness are of the greatest importance. During the first stage, that of infiltration, the use of nitrate of silver must be avoided, and not till the discharge begins to flow, must it be used; a five-grain solution is generally strong enough. In the beginning, a mild astringent lotion of borax, ʒi to one quart of water, will give relief if allowed to run through the palpebral fissures; later the nitrate of silver is to be applied. The dietetic treatment in these cases is of the greatest importance. The child must have good nourishing diet at regular intervals. It is also necessary in most cases to improve the digestion of the little patient. The following mixture has done me great service: ℞. Fl. extr. rhei. ʒi; sodæ bicarb. ʒij; aq. menth. pip. ℥iv; tinct. zingib. ʒss; tinct. nuc. vom. gtts. x. D. S.—A teaspoonful to be taken three times a day. Later, a tonic of quinine and iron, and in smaller children the ferrated elixir of iron and peruvian bark should be given in dessertspoonful doses three times a day.

Diphtheritic Conjunctivitis.—This is perhaps the most serious of all conjunctival inflammations, but fortunately it is but seldom met with in this country, it is seen much oftener in Europe. It appears sometimes in regular epidemics, but oftener in isolated cases. Like the croupous affection, it will attack especially children between the ages of two and five years, that are reduced in health, badly nourished, and covered with eczematous patches of the head and face, and also of the lids; it may make its appearance also in the course of a blennorrhœic attack. It is seldom preceded by diphtheria of the throat and nares, but it may travel to the nose and throat from the eye. The principal feature of this disease is a deep infiltration of all the tissues of the conjunctiva with a fibrinous material, which on the surface of the conjunctiva appears in the shape of a dense grayish membrane. The lids become very tense, and the injection and the exudation give them a peculiar yellowish appearance. They are so densely infiltrated that it is very hard to turn them; the upper lid especially becomes very stiff and heavy. If we succeed in everting the lids, we find them covered with a grayish membrane and easily bleeding. The chemosis is also tense and thick. The discharge, in the beginning quite scant and serous, becomes thick and copious in the later stages; it is very acrid and produces fissures and excoriations of the lids. These excoriations become very soon covered with the same grayish membranous exudation. This is one of the most characteristic features of the disease, and especially is the lower lid covered with these sores. It may even affect the anterior nares, by travelling through the lachrymal passages. The membranous exudation affects generally the whole inner surface of the lid, but we meet also with cases where it appears only in plaques. The disease is very contagious, and especially if the discharge comes in contact with sores of the face or other parts of the body, they will also be covered with a diphtheritic membrane. The danger to the cornea depends greatly on the extent of the disease and whether it will also affect the ocular conjunctiva. The cornea becomes generally affected after the disease has existed for some time, and may suffer even in the latest stages of the disease, and differs in this respect from severe blennorrhœic troubles in which the cornea becomes affected very early. The course of the disease is slower than in the croupous variety. The stage of infiltration will last several days, and even a week may elapse before the disease enters the blennorrhœic state, characterized by a purulent discharge, in which stronger remedies, like nitrate of silver, can be used. We have, therefore, three stages of this disease which differ very much in regard to appearances as well as in regard to the treatment required. The first stage is that of infiltration; it may last for six days; there is only a little serous discharge from the eyes but great pain in and around the eye, and dense infiltration of the lids. There is local heat of the lid and face and great irritability of the patient; both eyes are generally affected about the same time.

The second, or blennorrhœic stage, is characterized by a profuse purulent discharge mixed with bloody serum; the conjunctiva is red, and only small patches of the membranous deposits can be seen—the rest of the fibrinous deposit has broken down and has been discharged with the pus. The cornea is apt to suffer now. This stage may last a long time, but is free from pain. The third stage is that of repair. This is sometimes exceedingly slow, and is accompanied by the formation of cicatricial tissue, which in many cases will not only alter the appearance of the conjunctiva, but also that of the lids. The conjunctiva may form a whitish dry membrane, containing but few blood-vessels, and the changes in the lid may produce ectropium or trichiasis.

Treatment.—The treatment of diphtheritic conjunctivitis requires a great deal of care, but it is such a serious trouble, that it is apt to lead to serious consequences in spite of all our precautions. Fortunately the disease does not appear to be as formidable here as in Europe, especially in the northern part of Germany. As the disease is greatly favored by a bad state of health, it will be well to give the general treatment our earliest attention.

The best remedies for this purpose are quinine and iron. Quinine should be given in one to three grain doses three times a day. Iron for children is best given in the form of the pyrophosphate; ℞. Ferri pyrophosphatis, ʒj; syr. simpl. ℥iij. S.—Give the child a teaspoonful three times a day after eating (Derby). If a preparation of iron is given, it is well to give occasionally a mild cathartic, but the pyrophosphate of iron produces hardly any constipation. Good nutrition is of great importance; fresh eggs and meat should be given freely.

Of the local remedies cold compresses must be used during the first and second stages of the disease, as in purulent ophthalmia, see page 88. During the first stage mild antiseptic lotions may be used, such as the boracic acid lotion, twenty grains of boracic acid to a pint of water, or carbolic acid, ten drops to a pint of water. If there is extensive destruction of the cornea, use a stronger antiseptic lotion, composed of one part of chlorine water and three parts of plain water. This is to be dropped into the eye, a few drops every hour. These are to be used also for cleaning the eye. Antiphlogistic remedies are only advisable in very few cases, when robust children contract the disease by contagion. During the second stage, the free use of nitrate of silver is indicated in a ten-grain solution or in the shape of the mitigated stick (one part of nitrate of silver and two parts of nitrate of potassa fused together). The application has to be made twice a day in very severe cases, but generally once a day is sufficient. Great cleanliness and frequent applications of the disinfecting lotions must be resorted to. In the third stage, tannin, grs. xx, to one ounce of glycerine, is the best local remedy; apply it every day to the conjunctiva of both the upper and lower lids. Later, warm water applications are of great benefit, especially if there are remains of corneal troubles. The treatment of the corneal complications are the same as given on page 91 for the treatment of purulent ophthalmia.

(7.) *Chronic Blennorrhœa, Granulated Lids, Egyptian Ophthalmia, Trachoma* (Fig. x.)—This is a very chronic disease; it is characterized by a hypertrophy of the conjunctiva, especially of the papillary layer, and also by neoplastic formations in the shape of tubercle-like aggregations of round cells, which project over the surface of the conjunctiva, and are especially found in the fold of transmission. They resemble little warts, and can be pressed out of the surrounding tissue, when these cell conglomerations look like the gelatinous contents of a cyst. The surrounding tissue becomes very thick. During the first stage of the disease a mucous, occasionally in severer cases, a muco-purulent discharge will accompany it. The discharge is not abundant and may disturb the patient only by getting over the cornea and interfering with his vision.

During the night this may evaporate on the free edge of the lid, gluing the lashes together. This stage may last for a long time, even for years, without causing the patient enough inconvenience to seek medical advice. During this stage, sub-acute inflammatory attacks occur very often, on the slightest provocation; the conjunctiva which had been pale or but slightly congested, becomes now very red, œdema of the lids, chemosis, and a profuse muco-purulent discharge follows—in fact the picture of an acute blennorrhœa supervenes that of the chronic process—acute granulations. Corneal affections are apt to follow such an attack. This acute stage, however, does not last very long, and the chronic state is soon reached again. The second stage is characterized by the formation of cicatricial tissue. The granular bodies disappear, in few cases by fatty degeneration, but in most cases they leave deep bands of cicatricial tissue running through the conjunctiva, changing it very much in appearance, and interfering with its functions.

The soft smooth membrane has been changed into a hard irregular tissue with only a few blood-vessels. The secretion of its follicles is diminished, and the membrane itself is shrunken considerably. The deep cul-de-sacs it formed in its natural state are now almost obliterated, and cicatricial bands extend from the lid to the ocular conjunctiva. The contraction of the conjunctiva produces great changes in the lids and in the cornea. During the latter part of the disease, the upper lid becomes very heavy and thickened, so that the patient cannot lift it up as perfectly as usual; this gives the patient an unusually sleepy look. It is a semi-ptosical condition of the lid. The conjunctival surface of this heavy lid is very rough from the hard granulations.

These are rubbing constantly on the upper portion of the cornea, and in a short time will cause some loss of epithelial cells, and a rough, irregular surface of the remaining portion of the epithelial layer is produced; into this the vessels of the conjunctiva will extend and form a condition which is known by the name of pannus. This may become very heavy and thick, and interfere with the nutrition of the cornea, predisposing the tissue to ulcerative processes. Later, as the contraction of the infiltrated tissue of the lids and of the conjunctiva progresses, changes in the curvature of the lids will follow; entropium or trichiasis is apt to develop.

Causes.—The disease is frequently the result of neglected catarrhal inflammation, or may follow after the severer forms of blennorrhœic processes of the conjunctiva; most frequently, however, it is the result of contagion, and it is also observed as an idiopathic disease. As such it affects, with preference, those classes of society that are forced to live in badly ventilated or filthy places, whose general health has been reduced by exposure, insufficient food, and want of cleanliness. It is, therefore, apt to develop in our country, especially in almshouses and prisons; and as the disease spreads with great preference amongst children, our reformatories and orphan asylums have been the most productive source of the spread of this dreadful disease. Certain nationalities suffer much more than we do from this trouble, the Oriental races, especially the Egyptians and Turks; nearly one-half of them have granulated lids. The Jews and the Irish are blamed by English authors (Nettleship) for spreading the disease all over the world. In some parts of our western states and higher territories, and also amongst the negroes, the disease is comparatively unknown. The disease gives so little trouble during the first stages, that the patient may have it for years without being aware of it, spreading it at the same time amongst those he comes in close contact with. The contagion is, of course, due to infection by the secretion of the eye; when there is no discharge, there is little or no danger. If the disease is preceded by conjunctival inflammations, it will begin as small, red irregular bodies, like grains of sand, as we often see these in catarrhal conjunctivitis along the fold of transmission. They come from the papillary layer. These bodies, if not properly attended to, will from a continued low inflammatory condition, become hypertrophied by cell infiltration, which will soon spread to the surrounding tissue. These accumulations of cells are directly connected with the deeper conjunctival tissue, by radiating proliferations. Also new blood-vessels develop in these bodies.

If the disease is an idiopathic affection, it begins usually in the conjunctiva of the lower lid, with slight catarrhal symptoms. Very soon small round bodies, which look like frog-spawn or boiled sago, develop; they are semi-transparent and arranged in rows, starting from the lower fold of transmission they spread rapidly over the entire surface of the tarsal conjunctiva. They appear under the microscope as well defined lymph follicles; the rest of the conjunctival tissue is infiltrated with lymph cells, which in some places form aggregations of considerable size (Saemish). This form has been called (8)—*Follicular conjunctivitis;* it affects especially children. If seen early, and if promptly attended to, and if the general condition of the patient is improved, they will disappear entirely without producing great changes of the conjunctiva, but if neglected the disease may lead to cicatricial changes. It is also frequently found that the two varieties exist together.

The duration of this disease, granulated lids, depends on the attention that is given to it; but even under the most favorable circumstances it will last for many months, and the more indolent forms may last for many years in spite of all our efforts.

Complications.—The inflammatory process, affecting also the ocular conjunctiva after existing in the fold of transmission for some time, will reach that part of the conjunctival layer extending over the cornea, the limbus, blood-vessels, direct continuations of the conjunctival vessels, become visible, even small granulations will be seen at the margin of the cornea. The epithelial layer of the cornea becomes loosened and the blood-vessels will spread into this layer and a new vascular tissue will be seen to extend over the surface of the cornea, (pannus,) this being constantly irritated by the rough condition of the upper lid, may become very thick and vascular forming a fleshy mass overlying the cornea, *pannus crassus.* It begins on the upper margin and will in some cases spread over the whole cornea—*total pannus.*

The pannus may disappear again entirely, and if the anterior elastic lamina did not become implicated, the cornea may become perfectly clear again; but often slight cicatricial changes will remain permanent, causing a thin whitish film to extend over a part or over the whole cornea; the cornea appears hazy and dry, *pannus siccus,* and may remain permanently affected; if the thickening is dense, it may cause complete blindness. In the pannus itself sloughs may form, or the pannus may interfere with the nutrition of the cornea and cause ulceration of it. In these cases maculæ of the cornea will remain after the rest of the cornea has cleared up.

The long continued inflammatory process will eventually extend to the lid itself. The edge of the lid, the tissues in which the hair-bulbs are found, later the muscular layer and even the cartilaginous tissue, becomes affected, resulting often in entropium or trichiasis. During this stage the upper lid becomes so large and heavy that it cannot be raised entirely (*partial ptosis*), and the lower lid may become so heavy that the orbicular muscle cannot retain it in close apposition to the eyeball; the conjunctiva becomes exposed and thickened, until at last it becomes everted (*ectropium*). The inflammatory process may extend also to the lachrymal sac, producing a dacryocystoblennorrhœa. The sequelæ of the disease are principally caused by the contraction of the infiltrated tissues; this as we have seen results also in the formation of a whitish, hard cicatris of the conjunctiva (*trachoma*), and in a shrinking and abnormal curvature of the cartilage of the lid, producing sometimes entropium. The changes in the tissue surrounding the hair follicles causes an abnormal direction of the lashes (trichiasis).

Treatment.—Granulated lids, in an acutely inflamed condition, may require prompt local treatment, the same as acute blennorrhœal troubles, such as ice compresses and leeches; but as a rule the disease is so slow and asthenic in character, and associated with such a low, debilitated state of the system, that hygienic measures become of the greatest importance.

Change of air and better surroundings will often benefit the patient more than all local remedies. It becomes, therefore, necessary to see that the patients are well nourished, that they have plenty of out-door exercise and keep themselves clean. They should, however, not expose themselves to colds, which might bring on an acute inflammation, to which patients with granulated lids are especially predisposed. It is a very dangerous habit which these patients have to wash their heads, but not drying their hair sufficiently afterwards; wet feet must also be avoided. The patient should not be exposed to bright lights too much; especially reading or writing by artificial light will cause much irritation and should be avoided. The greatest care should be taken to prevent the spread of this trouble, if it shows itself in crowded institutions. The patients should be kept entirely separated from the rest of the inmates, having their own school-room, playground, and sleeping apartment, and separate towels and wash-basins, with the name of the patient on them, should be given to them. As the disease, especially in children, may exist without causing any outward signs, it should be the duty of the medical attendant to examine the eyes of all the children at regular intervals, say every three months, and great care should be exercised in the admission of new children, especially if they came from similar institutions. Such children should not be admitted to an institution which is free from this trouble under any circumstances, because if the inmates become once affected, it may take many years of careful attention to eradicate the trouble again. The use of one large towel for a large number of inmates should not be tolerated under any circumstances; each inmate should keep a separate towel for his own use, and keep it apart from those of the rest, just as he does his own clothing.

The local treatment calls for the use of very powerful astringents, especially if an acute inflammatory action preceded the condition. Of these the nitrate of silver again seems to do more good than any other preparation; it may be used in a five-grain solution, but in very old indolent cases the mitigated stick composed of one part of nitrate of silver to three parts of nitrate of potassa, fused together, enjoys a great reputation, and is in the hands of the "travelling oculists" which are sometimes found in this country, the magic stick that fills their pockets and brings them reputation. It is not necessary to wash the conjunctiva off after these applications in very sluggish cases; if otherwise the application causes too much irritation, it is best to wash the superfluous silver off. The objection to its long continued use is the staining of the tissues and even of the cornea, that it will produce argyrosis, and that it will lose its beneficial effect if used too long. In fact it is of the greatest help in the treatment of this tedious disease to change the remedies occasionally. The sulphate of copper in substance may be substituted in such cases. I have seen very obstinate cases improve rapidly by making alternate applications of the silver and copper once a day, but in most cases one application every second or third day is all that is required. These applications are quite painful to some patients and their effect may last for a long time, preventing them from doing anything on the day the application is made. If this is the case a milder astringent has to be used. For this purpose lapis divinus, which is composed of alum, sulphate of copper and camphor is of a great service, or the use of the tannin in powder. If the eye is very sensitive and feels hot and dry, a solution of tannin and glycerine may be used. The strength of this preparation should vary according to the irritable state of the conjunctiva; some persons will not bear a stronger solution than twenty grains of tannin to one ounce of glycerine. In very irritable cases we must be satisfied with the use of the alum in stick form or in solution, or with a solution of boracic acid ten grains to one ounce of water. The follicular variety is generally treated by milder astringents, say tannin or alum; if they are very obstinate, pale, with great thickening of the conjunctiva, a five-grain solution of nitrate of silver may be used, but it should be washed off with water; in very tedious cases of this kind the sulphate of copper will answer best.

In the selections of astringents for granulated lids we must be guided by the amount of irritation they produce. It is necessary, and the object of such applications is, to set up a certain amount of irritation and vascularity in order to cause the absorption of the inflammatory products; and it is claimed by many that astringents are not necessary for this purpose, that they attain the same object by rubbing the conjunctiva briskly with a rough substance, a small piece of carpet for instance; but I doubt whether it is safe to rely upon this alone in subacute or even chronic cases of granulations. If we find that our applications set up more irritation than is necessary, or cause even inflammatory conditions, we must substitute milder applications for it. The principal object in making such applications is to bring the remedy in contact with the favorite seat of the granulations, *i. e.*, the upper fold of transmission; from here it is easy for the medicine to spread all over the conjunctival surface. It is therefore necessary to have this fold well exposed while making an application; this is done best by directing the patient to look downwards and then everting the upper lid as thoroughly as possible. The eversion of the lid is very easy in many of these cases, but where there is much irritation or blepharospasm it may be very difficult. Treatment of the complications of granulated lids: if it is a dacryocystoblennorrhœa, it should be operated upon at once, as the irritating, septic discharge from the sac will continually add to the conjunctival trouble. Pannus in its earlier stages requires hardly any special attention; it will disappear during the use of the nitrate of silver or the sulphate of copper and with the improvement of the conjunctival trouble. If the pannus, however, is very extensive and vascular, threatening the sight of the patient, it should be touched with sulphate of copper freely, or it should be relieved by either removing the cause, by diminishing the pressure and the constant irritation caused by the upper lid, or by depriving it of the conjunctival blood supply, if it is of a very vascular kind. The first object is accomplished by making a canthoplasty, if the lid is drawn tensely over the eyeball, so that it is difficult to evert it; or the lid may be lifted away from the cornea, by fastening the lid to the forehead by means of sutures passed through it and the skin, but as this is objectionable in a great many cases, especially in girls or women, the lid may be held up by bands of adhesive plaster fastened to the edge of the lid and to the forehead. The best plaster for this purpose is the rubber adhesive plaster made by Seabury & Johnson, which will not loosen its hold by getting soft through the heat of the lid as the common adhesive plaster is apt to do. In such cases, where there is little or no discharge, and especially if there are ulcerations of the cornea present, a firmly applied bandage will do much good. It prevents the rubbing together of the two rough surfaces, and by compressing the granular bodies it will hasten their absorption. Such a bandage should be renewed every four or six hours; it should not be used at all if there is much secretion from the eye. The other method is to divide the conjunctival vessels before they reach the cornea, and thus deprive the vascular pannus of its source of nutrition; this is called peritomy or syndectomy. After the patient has been etherized, a speculum is introduced and the eyeball steadied by means of the fixation forceps. A concentric piece of conjunctiva and subconjunctival tissue, down to the sclera and near the cornea, about 2mm. wide, is now removed by means of scissors and scalpel. Ice applications are necessary to prevent inflammation. In milder cases division of the vessels near the corneal margin by means of a scalpel may be sufficient to cause great improvement. If there is much pain and photobia present in cases of pannus, the moderate use of atropia and occasional warm applications to the eye will afford great relief. In old cases of dry pannus, causing great impairment of vision, it has been noticed that it will disappear after acute relapses or new attacks of inflammation; these have been brought on on purpose, by inoculation with the purulent discharge of fresh cases of blennorrhœa, and they have in many cases done very much towards clearing up the cornea. Another form of pannus is that produced by the mechanical irritation of inverted eyelashes; it differs from the pannus due to granulations, because it may occur in any portion of the cornea wherever the cause is at work, whilst that due to granulations starts always from the upper portion of the cornea, although it may spread all over the cornea, if the irritation is kept up long enough. The pannus caused by the rubbing of lashes is, as a rule, not so vascular as the other varieties.

It will disappear readily if the lashes are removed, but the use of a little atropia may be indicated if there is much ciliary injection and pain. My remarks on the treatment of granulated lids would not be complete if I did not protest against the use of sugar of lead, especially if there is pannus with ulcerations of the cornea, nor can I advise the abscission of prominent granulations, as this will surely produce marked cicatrization.

The localized inflammations of the conjunctiva are either traumatic or phlyctenular.

(9.) *Conjunctivis traumatica* is not only caused by the presence of a foreign body, but it may be due to any kind of an injury; very often it is due to burns, especially to burns of caustic lime or potash or to acids, like the oil of vitriol. In these cases the conjunctiva as well as the cornea is apt to suffer. Foreign bodies may remain in the eye sometimes for weeks without causing much trouble, especially if they get into the lower cul-de-sac of the conjunctiva, but if they are near the edge of the lid they will irritate the eye immediately. The symptoms are a sensation of burning, or a gritty feeling; there is lachrymation, photophobia, and if the irritation is continued long enough, there may be seen ciliary injections; there is pain, especially on moving the eye, that may change from one location to another.

Treatment.—The cause of the disease must be removed, if it is a foreign body. In order to examine the conjunctiva thoroughly, let the patient look up while you are pulling down the lower lid, or make him look down while you are everting the upper lid. The foreign body is most apt to be within a short distance of the edge of the upper lid or in the lower cul-de-sac.

If the foreign body has penetrated into the conjunctiva of the eyeball, and the opening has closed over it, it may be necessary to excise a small piece of conjunctiva in order to remove the foreign body with it. Wounds of the conjunctiva have to be treated by cold applications and rest. Incisions in the conjunctiva will heal very rapidly, and even the loss of a large surface of it will be reproduced in a very short time, but of great danger is it, if two wounded surfaces lie in close apposition; they are very apt to heal together, to unite. This is the greatest danger in burns of the conjunctiva, whether they have been caused by heat or by chemicals. Of all of these, burns of lime are the most frequent, and also the most dangerous. Sulphuric acid produces a burn that will turn black after a little while; burns of nitric acid assume a yellow color, but caustics and especially lime produces a sore covered with a detritus of an ashy gray color. Great conjunctival congestion will surround the wounded spot, and even the whole of the conjunctiva will participate in the process.

The first step after such accidents must be the neutralization of the acids by alkalies, and of alkalies by acids. To neutralize acids after they have gotten into the eye, a mild solution of bicarbonate of soda should be used; for alkalies, the best acid readily obtained is either vinegar or lemon juice; they ought to be diluted sufficiently and used very freely to wash out the affected eye; but unfortunately we do not see most of these cases until the agent has spent all its force on the tissues of the eye. In burns caused by lime, which is usually in the form of mortar, we must be careful to remove all the pieces of sand and lime composing it. After this has been done, the conjunctiva should be washed off with diluted vinegar. The greatest danger in these injuries by burns, is the fact that the substance getting into the eye will burn the conjunctiva of the bulb as well as that of the lids, producing two raw surfaces which lie in close apposition. The swelling, which sets in now, may keep the eye closed for a short time, and if the patient after several days can open his eye again, he finds that the eyeball and lid are firmly united. The edges of the lids are apt to suffer also when the caustic enters the eye, and if the eyes remain closed for some time afterwards, they may entirely grow together, forming an anchyloblepharon. In order to avoid the formation of these dangerous lesions, the greatest care should be used to keep the lids apart till the wounds have entirely healed. This is best accomplished by dropping fat, and by preference, a very thick sticky oil, such as castor oil, into the eye, as often as every half hour, and drawing the lid away from the eye very often. Should during the night some adhesions have formed, these are easily torn apart by means of a strabismus hook. The bleeding which follows is of no harm, yet care must be taken to tear the tissues as little as possible. This is to be continued with the greatest perseverance until the wounds have healed. As an operation for a symblepharon is followed by so many failures, we must try to prevent the formation of it if possible. Another form of a traumatic conjunctivitis is that caused by the use of atropia. Although the atropine may be used in thousands of cases without the slightest unpleasant effects, we shall meet with cases where it is not tolerated. Not only will it produce pain and itching at the time it is introduced, but it will cause great hyperæmia, roughness of the tarsal conjunctiva and swelling of the lids. The skin of the lids becomes red, glazed, and excoriated. Old people, and especially ladies, are apt to suffer from this peculiar idiosyncrasy.

In other cases the atropia may have been used for many weeks, when gradually a very annoying conjunctivitis sets in, which seems to be kept up and is increased by the atropine. In such cases a small quantity of sulphate of zinc, one grain, or boracic acid, three grains, may be added to one ounce of the atropine solution. Touching the conjunctiva occasionally with a little alum will also be useful, especially in cases where atropine has to be used for any length of time. In these cases, wherever a few drops of atropine set up much irritation, another mydriatic, the buboisine or daturine must be used instead of it. The conjunctivitis thus produced is speedily relieved after the mydriatic has been changed, by a mild solution of borax or boracic acid, and the irritation of the lids is benefited by the application of glycerine or the benzoated zinc ointment. ℞. Zinci oxydati albi, ʒ ij; ungt. benzoati, ℥ ss. M. ungt. S.—Apply three times a day to the affected lid.

(10). *Conjunctivitis Phlyctenularis Scrofulous Ophthalmia, Herpes of the Conjunctiva* (Fig. xi.).—The peculiar feature of this disease are small, yellowish elevations, on the apex of which small transparent vesicles form; these burst and leave small ulcers with a depressed centre and elevated margins. The infiltration is a subepithelial one, consisting of round cells. The epithelial layer itself is raised by serous exudations in the shape of a vesicle, this is very thin and will rupture early, leaving an ulcerating surface. This process is due to an irritation of one of the terminal nerve fibres, and is principally a disease of childhood, affecting by preference children of a strumous diathesis, or badly nourished children; it occurs frequently at the period of dentition.

In this case it is apt to precede the cutting of the teeth, and will subside often even without medication, soon afterwards; it may come on at any age, after errors of diet, especially after a liberal supply of candy or cakes; it may also be caused by exposure to wind and dust; it is therefore more frequent in spring and fall, or it may be caused by the vitiated state of the air of sleeping apartments, and it is perhaps on this account, that we see it so frequently after measles or scarlatina, and that the disease, so frequent in the large cities, is rather rare in the country. It may also develop during an attack of catarrhal conjunctivitis.

The disease is most troublesome in the morning; the children hate to leave their bed until late in the day, but they improve towards evening. There is generally only a limited congestion of conjunctival vessels in the shape of a regular leash of vessels, running from the phlycten to the fold of transmission; but in severe cases the whole conjunctiva is inflamed. There are two varieties of this disease, the one is called the small phlycten, and the other the large or broad phlycten.

Small phlyctens are by far the most frequent. Sometimes one or two may be present, but they appear generally in large numbers, and as their favorite seat is the limbus, they may surround the cornea like a string of beads; then they seem to encroach upon the cornea itself at times; the little vesicles are densely crowded together, and after these are ruptured, the phlyctens will coalesce and form now an elevated ring of infiltration around the cornea. The conjunctival injection in such a case will resemble a ciliary injection, because the vessels seem to radiate from the cornea, but they are quite superficial and much larger than the ciliary vessels, they are also of a lighter color.

The subjective symptoms are much more intense than those of the other variety; it is also much more obstinate to treatment and liable to many relapses.

The other variety is that in which the phlyctens are broad and large; they are generally only few in number, seldom more than four or five. They are often some distance from the cornea in any portion of the conjunctiva, but they will also be seen on the limbus. The yellowish vesicles that form on the slight elevation will soon rupture and leave a large depressed ulcer with whitish exudation in the centre, resembling very much a hard chancre. From the seat of the disease a large number of large vessels run towards the fold of transmission; they are more or less grouped together, and the conjunctival injection is generally limited to the single band of vessels. The symptoms of this form of the disease are not marked; it gives the patient but little trouble and it will yield readily to treatment. It is generally found in young persons at the age of puberty.

The symptoms of both forms of the disease are about the same. There is suddenly great dread of the light; the child that has been playing around usually, prefers dark corners, where it will sit for hours with its eyes tightly shut. This is especially marked in the morning when the child hates to leave the bed, burying its head in the pillow till noon, if allowed to stay there. If the child is brought to the light, it will protect the eye with its hands or by the arm of the mother, and if forced to look up, the affected eye will be tightly shut by powerful contraction of the orbicularis. Blepharospasm may be present in such cases to such a degree, that the whole side of the face of the affected eye is drawn into wrinkles, which will form quite a contrast when compared with the other side of the face, if the other eye is free from the trouble. The lachrymation is very marked, the tears are not only abundant but acrid and scalding, producing excoriation of the edges of the lids and frequently also of the face. Passing down the nose they set up a considerable inflammation of the Schneiderian membrane and excoriations of the nostrils. Thick phlegm protrudes from the nose, and if this is removed, the skin becomes irritated, painful, and easily bleeding. On account of the sharp irritating discharge, we have the disease also frequently associated with blepharadenitis, mostly of a localized form, corresponding to the seat of the phlycten. After the vesicles have ruptured, there is generally an amelioration of the symptoms, but the disease can become extremely tedious and annoying to the patients; this is especially the case when the disease invades the cornea at the same time. This causes at once increase of the severity of the symptoms; photophobia, blepharospasm and lachrymation are very severe; the conjunctiva becomes very much inflamed and the lids,on account of being so tightly closed by the muscular spasm, become œdematous, and discolored on account of the impeded venous circulation; in chronic cases this may lead to a decided hypertrophy of the edge of the lid (*tylosis*)—especially is this the case in scrofulous patients. The nose also becomes very much thickened and inflamed, and large crusts will form around the nostrils. The pericorneal infiltration becomes at times very thick and vascular, and seems to affect the cornea, ciliary body, and sclera. The secretion is so acrid that excoriations of the lid and face will be extensive at times;this is generally favored by the desire of the children to have their eyes hidden or covered, to escape the irritating effects of the light; by the rubbing of the excoriations they will become large and covered with crusts (*eczema*). The course of the disease is comparatively short in the large variety; the small variety is tedious, especially if associated with corneal complications; it may last for many weeks or even months. It will generally disappear without causing any destruction of tissues.

Of the complications of this disease we have, besides those of the cornea,an inflammation of the free edge of the lid (*blephara-*

denitis), and if this continues for any length of time, hypertrophy of the lid and also eczema and coryza. It is only in severer and tedious cases, or after bad medication, that the conjunctiva becomes likewise inflamed, so that it may become difficult to determine which was the original disease. We have, however, this peculiarity of the disease, that it is always worse in the morning and better in the evening, which will help us to differentiate it from catarrhal troubles of the conjunctiva, which are always better in the morning but become troublesome in the evening, especially by artificial light. There is only lachrymation; no other discharge in phlyctenular conjunctivitis.

Treatment.—The treatment of a phlyctenular disease of the eye requires more dietetical and hygienic treatment than local medication, which, however, is of great importance in the majority of cases. The broad variety, under proper hygienic conditions, will disappear in a few days on the application of calomel, dusted into the eye. Also in the small variety the use of calomel is absolutely necessary. The calomel used for this purpose should be in a state of perfectly fine powder. In ordering it we should call for the hydr. subchlor. laevigatum, which means washed and triturated. The calomel should be dusted into the eye in severer cases once a day, later if the symptoms improve, every second or third day; the best way of applying it, is to dust it into the eye by means of a small brush, keeping both lids apart with the other hand. It is best to dust it on the phlyctenular pustule, but this is not absolutely necessary; it should be well scattered over the conjunctival surface. Great care should be taken not to throw too much of the calomel into the eye or to throw all on a small space; if this is done, it may accumulate in the lower cul-de-sac of the conjunctiva, and remaining here for a day or two, it will, on account of the chemical change taking place, which will transform the subchloride into a bichloride of hydrargyrum, produce not only irritation but deep burns. The change of the calomel into corrosive sublimate is due to the presence of salt in the tear-fluid. If the patient has been given iodide of potassium, or iodide of iron, this will be present in all the fluids of the body and also in the tear-fluid. If calomel comes in contact with such tears, it will be rapidly changed into an oxide of hydrargyrum, which is very irritating, and the use of calomel in such a case might do more harm than good. The same may be said of other preparations containing hydrargyrum, such as Pagenstecher's ointment, or the ointment of the red oxide of hydrargyrum. If the use of these preparations is indicated, the patient should not take any preparation of iodine for several days before or after their application. In the small phlyctenular variety the use of calomel should be continued, at longer intervals, for weeks after the disappearance of the disease, in order to prevent a relapse. This is especially necessary if, from corneal complications, maculæ corneæ should be present. The use of calomel is contraindicated if deep corneal ulcerations complicate the disease or where there is great ciliary injection. If there is much photophobia and lachrymation, atropia should be used moderately. In young children a strong solution of atropia will often produce very unpleasant symptoms, such as fever and great redness of the face or the whole body; a solution of homatropine, containing one grain to two ounces of water, should therefore be used. Milder forms of photophobia will disappear gradually after the use of calomel. In very severe and obstinate cases, when the calomel seems to be ineffectual, the use of Pagenstecher's ointment will be of great assistance. The original prescription called for one part of red oxide of hydrargyrum to eight parts of simple cerate, but some surgeons use it milder, others stronger; instead of the red oxide the yellow oxide of hydrargyrum has been used, five grains of this to one drachm of vaseline makes a very good preparation. In cases where the use of atropia is indicated, this may be added to it, say one grain to one drachm of the ointment. In applying the salve, take a small piece of the size of the head of a pin on a brush or a small piece of wood and apply it to the conjunctiva of the lower lid, and after closing the eye, distribute it all over the eye by rubbing the lids gently.

This is a more powerful preparation than calomel, and its application causes more pain and irritation. If large corneal ulcers are present, the use of iodoform instead of the hydrargyrum is indicated. ℞. Iodoformi, gr. x; atropia sulph. gr. j; vaseline, ʒ ij. S.—To be applied by the physician once a day.

Fissures and excoriations of the lids are greatly relieved by the benzoated zinc salve. Of the greatest importance is it, that the patients should be in dry and well-ventilated rooms; they should take much outdoor exercise, and have often a warm bath, especially a salt-water bath. The eyes should not be covered, even if the patient desires it. Against the light they should be protected by smoke or blue-tinted glasses, or a large shade over both eyes should be used. The patient's food should be given at regular intervals only, say three times a day; nothing whatever, not even milk, nor cakes or crackers or buttered bread should be given between meal-times. Meat and eggs should be given freely; potatoes and farinaceous food only sparingly; children more than ten months old should be taken from the breast at once, other circumstances permitting. Fruit may be given, but only at meal-times. In cases where there is much disturbance of the digestion, the mistura rhei et sodæ (see page 29), should be given, ʒi ter. in die; if there is a good deal of eczema and constipation at the same time, the mistura rhei et magnesiæ (page 30), will be better. Later a tonic preparation, the elixir of Peruvian bark and iron. ʒi to ʒii ter. in die may be given, and in scrofulous patients cod-liver oil in its pure state, or if the patient's digestion is bad, an emulsion of it with the hypophosphites may be given instead of it. Finally, I must again caution against using iodine preparations and calomel at the same time.

Granuloma of the Conjunctiva; Polypus.—Exuberant local granulations of the conjunctiva are sometimes seen near the opening of an old abscess, a chalazion, or near an old cicatrix, and also around foreign bodies in the conjunctival sac. In a normal eye, they can never obtain a very large size, and are of a peculiar shape. They are generally flat from the pressure of the lid and eyeball, with a very small pedicle; in very small, atrophied eyes, however, they become much larger. They are composed of simple granulation tissue, round cells with very little connective-tissue and many newly-formed blood-vessels. They can be easily removed by cutting them off with scissors, and touching the pedicle with a stick of nitrate of silver. Care must be taken not to return the lid to its normal position before all the superfluous nitrate of silver has been neutralized and washed off.

Epithelioma and other cancerous affections of the conjunctiva are very rare; they generally start from some neighboring tissue, implicating the conjunctiva later.

Pinguecula.—This is a small yellowish elevation, found in the epithelial layer of the conjunctiva over the internal rectus muscle, and at times over the external rectus. It is composed of an accumulation of epithelial cells, and not of fatty cells, as was first supposed. It is probably due to the mechanical irritation of dust accumulating at these places. It will not grow very large, and seldom reaches the corneal margin, and it will never grow upon the cornea. It is a very harmless affair, as it remains stationary after reaching a certain size, and does not require any treatment; but if it is desired to remove it for cosmetic purposes, this can be done by grasping it with the forceps and abcising it with a pair of curved scissors. A fine silk suture will suffice to bring the parts neatly together; this may be removed after thirty-six hours.

Pterygium—little wing—(Fig. xii.) is a portion of the conjunctiva that is drawn over the cornea. It is caused by a peripheral injury or ulceration of the cornea; in the healing process the conjunctiva is drawn into the wound. By the continued irritation of dust and other irritating causes, the ulceration will progress farther over the cornea and draw the conjunctiva also farther over it. On account of its exposed position, this fold of the conjunctiva will become more vascular and slightly hypertrophic.

The pterygium is triangular in shape; its apex may extend to the centre of the cornea and its base from the periphery of the cornea to the conjunctiva and generally toward the inner canthus. It may remain stationary at any point, but it will generally travel to the centre, and if it does this, it will interfere with the patient's vision. It is caused by slight peripheral ulceration of the cornea, such as are formed in severe cases of catarrhal or in phlyctenular conjunctivitis, or they may have been caused by small foreign bodies and particles of dust or by a slight scratch with a finger nail. We find them, therefore, of more frequent occurrence among coal miners, or workmen employed in a dusty atmosphere, such as masons, carpenters, etc. For these reasons it is of more frequent occurrence in males than in females and in older people, because with them the cornea is more apt to become ulcerated than in young men. In the young the conjunctiva is also more tense and not so apt to be drawn away from the sclera. In the beginning, and as long as the pterygium is progressive, it is apt to be very vascular, but if cicatrization of the ulcer takes place, which generally occurs if the centre of the cornea is reached, the vessels will mostly disappear; the pterygium is now paler, transparent, with ridges radiating from the apex to the base, which gives it the appearance of an insect's wing. If the contraction of the pterygium becomes marked it may interfere with the outward movements of the eyeball and give rise to diplopia; this is, however, not of frequent occurrence. It is seldom that any unpleasant symptoms occur, except an uncomfortable feeling and a deformity which is produced by it. It is generally found on the nasal side of the cornea, and sometimes on the temporal side, but it may occur at any portion of the corneal margin.

Treatment.—Early in the beginning of a pterygium we can heal the corneal ulcer by touching it with nitrate of silver or copper, and stimulate the absorption of the small conjunctival fold by the use of alum or tinctura opii crocata; but surgical interference is more reliable, and it is indicated for cosmetic purposes, or if the pterygium becomes hard and rigid and gives rise to diplopia, or if it advances far enough on the cornea to disturb the vision of the patient. I have used two methods with great satisfaction. The first is Arlt's operation. The patient is etherized: an eye speculum is introduced and the pterygium is dissected off from the cornea, from its apex to the point corresponding to the margin of the cornea, by means of a fine scalpel. It is now seized and removed together with a piece of the conjunctiva. This piece is to be triangular, and to point to the inner canthus, the base to correspond to that part of the margin of the cornea where the corneal portion had been loosened. The conjunctival wound is now united by two or three sutures of fine black silk, so that the growth of the conjunctiva is directed toward a horizontal line and not toward the cornea. The corneal wound will remain somewhat cloudy for some time after the operation, but it will as a rule heal and clear up very considerably. Another operation is that of Szokalsky; it consists in introducing three sutures under different portions of the pterygium and strangulating it by drawing the sutures together. This is apt to take more time to heal, and will not always give very satisfactory results. A modification of Arlt's method consists in dissecting loose not only the corneal but also some of the conjunctival portion of the pterygium, not to cut it off, but to turn it under the conjunctival portion and bring the conjunctiva together over it by sutures applied near the corneal margin. The point of the pterygium will shrink and become absorbed, and the line of growth is turned in exactly the opposite direction, that is away from the cornea.

Xerophthalmia is that condition in which the whole or the largest portion of the conjunctiva has been changed into cicatricial tissue, with complete destruction of its glands and follicles. The conjunctiva is not only shrunken, but it is changed—it is hard and dry, the cornea soon becomes opaque and the eye is lost. It is generally caused by extensive burns, granulated lids, and by trichiasis. It may be palliated by applying oil and glycerine to the conjunctiva, but it cannot be cured.

CHAPTER VI.

THE CORNEA.

THE cornea is the clear, transparent, anterior portion of the eyeball; it is the first and most exposed portion of the dioptric apparatus; all the light that gets into the eye has to pass through it. It is therefore necessary that it should be perfectly clear, and any disease of the cornea is of great importance, because its transparency is exposed to danger, and loss of vision may result from it. The cornea forms an oval with its longest diameter in a horizontal direction. Its anterior surface is convex, its posterior surface is concave.

The cornea is only 1 mm. thick, but its tissue is firm, resisting and will stand a great amount of injury without difficulty; it has the peculiar property of allowing fluids to penetrate its tissue, thus enabling medicines, such for instance, as atropine and eserine, to act on the deeper tissues. Man has only one, some varieties of insects have nearly nine thousand corneæ. The cornea is composed of several layers; the first is an epithelial layer, then comes an elastic lamina, Bowman's membrane, under this the corneal tissue proper, and next to this the posterior elastic lamina or Descemet's membrane, and lastly another epithelial layer. The superficial epithelial layer is continuous with the epithelial layer of the conjunctiva. The most superficial layers are composed of flat tesselated epithelial cells, with a large nucleus; they are held together by a small amount of structureless cementing substance; next to this follow several layers of epithelial cells, more conical in shape, with small offsets, interlacing with each other; the deeper part is formed by a single layer of epithelial cells—it is the basal layer, its cells are conical. The cementing substance unites all these layers. The elastic lamina which lies next to the epithelium is called Bowman's membrane: it is perfectly structureless and thinner than the posterior elastic lamina; it gives to the cornea its peculiar lustre.

The corneal tissue proper lies between the two firm elastic laminæ, that of Bowman and of Descemet. It consists of a transparent stroma, formed of very fine fibrillæ, intersecting each other at different angles; they are united by cementing substance. A number of fibrillæ form a fascicle, and a number of these together form a lamella; these lie mostly parallel to the surface of the cornea. Of these lamellæ we have a large number, and they are all held together by the same cementing substance. Imbedded in the corneal tissue we find also a number of canals, intersecting each other and forming at certain places larger cavities called lacunæ; they are arranged in rows, lying in a parallel direction with the corneal surface. These canals are supposed to carry the nutritive fluid. The cornea contains also several varieties of cells; the fixed cells are generally found in the lacunæ; they are irregular masses of protoplasm with a large nucleus, and have small offsets. The wandering cells of the cornea are less in number; they wander through the canals, and are similar to the fixed cells. The pigmented cells of the cornea are few, they are found near the periphery, especially in negroes and are identical with the fixed corneal cells. On its inner surface this layer is protected by the elastic membrane of Descemet, which is very thick, strong, and elastic, so that it will wind itself up in a spiral manner if it becomes lacerated or detached. The inner layer is composed of a single row of delicate epithelial cells, which are also united by a cementing substance. At the periphery of the cornea, the superficial epithelial cells pass directly over into those of the conjunctiva. Bowman's membrane splits up and passes with the most anterior lamellæ of the corneal tissue into the conjunctival tissue, and the rest of the corneal tissue and its canals passes over into the lamellæ of the sclera. The membrane of Descemet splits up into fibres which pass into the connective tissue of the ciliary muscle and of the iris; adherent to these fibres are also endothelial cells resembling those of the posterior surface of Descemet's membrane.

This network of fibres is called the ligamentum pectinatum. Between these fibres are cavities and canals communicating on one side with the anterior chamber, on the other side with the canal of Schlemm, a lymph canal. This system of canals and cavities are called Fontana's spaces.

The blood-vessels of the cornea are derived from the anterior ciliary arteries; they do not pass into the cornea, as they would cause a diminished transparency of it. The superficial branches of the ciliary arteries run only into the most peripheral portion of the cornea; they anastomose with each other, forming small arcades in the margin of the cornea, the marginal loops; they anastomose also very freely with the deeper conjunctival vessels. The veins form in the periphery of the deeper layers of the cornea; they pass into the episcleral and then into the anterior ciliary veins.

The nerves being transparent, are found all over the cornea. They are derived from the anterior ciliary and also from the conjunctival nerves. They pass into the deeper layers of the cornea, forty to forty-eight in number, and branching off, they form the narrow stromaplexus; from this plexus branches are given off that have their termination in the epithelial layer of the cornea. The epithelial layer is, therefore, the most sensitive part of the cornea; a slight scratch on it will cause great pain. Photophobia is said to be due to the irritation of denuded terminal nerve fibres by light.

Pathology of inflammatory changes of the cornea. The slightest inflammatory action of the cornea will result in an increase of cells. These may be round or small spindle-shaped cells; they are called wandering or lymphatic cells, and are identical with the emigrated white blood corpuscles. They are the products of proliferation of the corneal cells proper, or they may have come from the marginal blood-vessels of the cornea. The result of an inflammatory action must therefore be an infiltration of some portion of the corneal tissue with these cells mostly. This infiltration may not be to such an extent as to cause a breaking down of the stroma of the cornea or altering it materially; it is often limited to a circumscribed portion of the cornea; if this is superficial, the epithelial layer will suffer from it, if deeper the epithelium remains unaltered. The infiltrated portion becomes thicker by proliferation and by serous infiltration (*keratitis phlyctenularis*); it is always surrounding a nerve branch and extends from Bowman's membrane into the epithelial layer. Again, the infiltration may be deep in the corneal tissue itself, more or less diffused through the whole of it; this is the case in the so-called parenchymatous or diffuse keratitis.

Again, the infiltration of cells may be accumulated at a certain place to such an extent as to interfere with the nutrition of this portion; this is, therefore, apt to break down, forming a cavity filled with pus corpuscles and debris of the broken-down tissue. If this cavity does not result in a break of continuity of the anterior or posterior surface of the cornea, it is called an *abscess*. If the process of repair sets in now, the contents of the abscess may be absorbed again, and the broken-down tissue reformed, leaving often no traces of the previous inflammation; or the process of repair may result in the formation of an opaque cicatrix. In other instances the pus-cells may gravitate to the bottom of the cornea, imprisoned between the two elastic laminæ. This is called an *onyx* or *lunula*, as it resembles the lunula of a nail of a finger. At times the sinking of the pus through the cornea can be distinctly seen as a thin whitish band extending from the seat of the infiltration to the onyx. In other cases the pus-cells will find their way through the membrane of Descemet without breaking down the membrane, and getting into the anterior chamber will settle at the bottom of it, forming a *hypopion* (Fig. xv.). These two conditions, hypopion and onyx, resemble each other somewhat, but by oblique observation the anterior chamber is found to be entirely empty in a case of onyx, and if the patient changes his position for any length of time, the hypopion will gravitate to the lowest portion of the cornea whilst an onyx will not change its position. An onyx is generally small; a hypopion may become very copious, and may fill the entire anterior chamber. The upper boundary of the hypopion is generally level, that of an onyx more or less concave and round.

Frequently, however, a break in the continuity of the corneal surface will take place; the abscess will be transformed into an *ulcer*. Ulceration may, however, begin primarily as an ulcer. An ulcer may progress superficially only, but generally also in depth, and if it extends through the whole thickness of the cornea, opening into the anterior chamber, it is called a perforating ulcer. Ulcers, if only superficial, especially if only in the epithelial layer, may heal without leaving any traces; but generally they will result in the formation of an opaque cicatrix, especially if the anterior elastic lamina has suffered. The healing process is ushered in by the formation of new blood-vessels in the corneal tissue proper, and in the ulcer. These blood-vessels disappear again later on. If the ulcer perforates, the aqueous humor of the anterior chamber escapes, and the iris is apt to fall forwards and is caught in the wound (*prolapse of iris*), where it is apt to adhere to the cornea (*anterior synechia*). Before the cornea is perforated, the strong membrane of Descemet will resist the intraocular pressure for some time and bulge forwards in the wound, this is called *keratocele*. The process of repair may begin at this point, but as a rule perforation will follow. Deeper ulcerations leave a dense cicatrix implicating a deep portion of the corneal tissue (*leucoma*); if the scar is the result of a perforating ulcer, and has the iris attached to it, it is called a *leucoma adherens*. As a rule the cicatrix fills up the space of the ulceration entirely, but sometimes a defect is caused by the epithelium only covering the depression, which on the surface of the cornea appears as a *facet;* it is generally transparent.

To recapitulate, we find that the symptoms of inflammatory processes of the cornea result in (1) a change of the peculiar lustre of the cornea, which is principally due to changes of the anterior elastic laminæ; (2) we find that the surface of the cornea is not even and smooth as in the normal state; (3) that the transparency of the normal cornea is more or less changed or entirely lost, and (4) that the normal curvature of the cornea may undergo great changes, become more globular, flatter, or even conical in shape; together with this we have (5) the ciliary injection and a number of subjective symptoms.

As results of keratitis we have opacities of the cornea; these may be very slight, (1) *nebulæ*, or they may be more opaque, (2) *maculæ*, or they are formed of dense white cicatricial tissue called (3) *leucoma*. These opacities, if associated with prolapse of the iris, are called (4) *leucoma adherens*. Dense infiltration, especially near the corneal margin, may be caused by formation of connective tissue between the lamellæ of the cornea, and may obliterate the corneal canals and lead to atrophic changes of these parts; it is called (5) *sclerosis of the cornea*. Maculæ of the cornea may be congenital, probably due to intrauterine diseases of the cornea; these are, however, not often met with, nearly all of them being acquired after birth.

Anterior synechiæ can occur after a perforation of an ulcer, or after a traumatism when the injury, operation, or foreign body has resulted in an opening of the anterior chamber. Usually only the iris is prolapsed and united to the wound, but the lens may be likewise prolapsed and included in the scar resulting from the wound. The pigment cells of the iris may stain the resulting leucoma dark or give it a bluish appearance if the iris becomes incarcerated in the wound. Anterior synechiæ between cornea and vitreous body are rare, and occur only after removal or dislocation of the lens. After a long continued ulceration we find the intraocular tension often increased, and if perforation takes place under such circumstances, the recently formed scar is frequently not strong enough to retain the normal curvature of the cornea —it will yield and bulge forward. *Staphyloma corneæ* (Fig. xvi.) If the scar is small and central and free from adhesion to the iris, the bulging portion will become conical in shape (*keratoconus*, or conical cornea). This cone is generally small and perfectly clear, but sometimes it will be so large as to project between the closed lids, and if it continues to increase, it may rupture. Perforation of the cornea is, however, of more frequent occurrence at the periphery and associated with prolapse of the iris; if bulging takes place in these scars, the staphyloma may be small and occupy only a portion of the cornea (*partial staphyloma*), or it may implicate the whole of the cornea and even the anterior portion of the sclera. This is called a *total staphyloma.* If the staphyloma is projecting between the closed lids, it will become hard, scaly, and dry; this is called *xerosis* of the cornea.

In the treatment of inflammatory processes of the cornea the following rules must necessarily be observed with very few exceptions. (1.) Avoid all irritating remedies, such as nitrate of silver or sulphate of copper, etc. (2.) Pay special attention to the surroundings of the patient and his general health. (3.) Atropia, rest, and protection from the irritating effect of light are always appropiate. (4.) Antiphlogistics, such as leeches, purgatives, and cold are only necessary in a few cases, where the symptoms are very severe, and where the general condition of the patient indicates their use.

According to the mode of infiltration, or to the different causes of a keratitis, we have divided them into different varieties. We have to speak of (1) a simple localized keratitis, of (2) a phlyctenular, of (3) a diffuse, of (4) a vascular, (5) a traumatic, of (6) a neuroparalytic, of (7) a bullous, (8) a specific, and (9) a suppurative keratitis.

(1.) *A simple keratitis* may affect persons in perfectly good health, after slight exposures, especially to draughts, or after sudden changes of temperature. It is accompanied by one or several small patches of infiltration that are generally quite superficial and faintly opaque. The symptoms accompanying it are: slight ciliary injection, sharp lancinating twitches of pain, not excessive however, considerable lachrymation and photophobia, especially dread of the direct sun-light or bright artificial light. It affects persons of all ages, and is generally accompanied by a general cold, and sometimes with a slight conjunctival catarrh, and in severe cases, with chemosis and œdema of the lid. It may appear as an idiopathic affection, but it is also found as a secondary condition, accompanying catarrhal inflammations of the conjunctiva, especially if they are neglected or maltreated. The treatment of this simple affection consists in perfect rest of the eye, which is greatly favored by a slight pressure bandage, or if this cannot be applied, by the use of blue glasses. A two-grain solution of atropia is to be used, two drops three times a day. Compresses of hot water or of an infusion of German chamomile flowers, are to be applied for ten or fifteen minutes three times a day, shortly before the atropine is used.

Antiphlogistic remedies, such as leeches and purgatives, are hardly ever called for, except in cases of robust persons, with severe pain and great ciliary injection. A hot bath, especially a vapor bath, will give immediate relief, and will relieve the inflammatory symptoms promptly. Quinine, in five-grain doses, mornings and evenings, is often of great service.

The disease is generally of short duration; the inflammation will disappear entirely in a few days, leaving no visible trace in the cornea.

Should the process of absorption be slow, the use of calomel is of great service in hastening it. In patients whose health is below par, it may through neglect lead to ulcerations of the cornea.

2. *Herpes Corneæ or Keratitis Phlyctenularis* (Fig. xiv.)—This form of keratitis is met with under the same circumstances that we have mentioned in phlyctenular conjunctivitis. In fact it is so much like this disease in all its causes and manifestations, the infiltration of the cornea being generally in the conjunctival portion of the cornea (the epithelial layer and Bowman's membrane), that by many it is looked upon as a severe form of phlyctenular conjunctivitis. It is often found to be associated with phlyctens of the conjunctiva, but in most cases the principal seat of it is in the cornea. The infiltration is generally in the epithelial layer of the cornea, but may extend as far as Bowman's membrane, and in very severe cases the ulceration may even perforate the cornea. The inflammation is circumscribed and always confined to the surrounding parts of one of the terminal branches of the ciliary nerves. Sometimes we see a slight elevation of the most superficial layer of the epithelium, caused by an accumulation of a serous fluid; but as this ruptures very early, it is only after the rupture of the vesicle and the formation of a small ulceration, that we see the patient. The seat of the small ulcer is generally peripheral, but we will see them at times as small central abrasions, with very little infiltration. In severer cases there is infiltration around the margin of the ulcer, which is apt to spread considerably before we are able to check it. The more peripheral manifestation of the disease has been described under the head of phlyctenular conjunctivitis. Sometimes a phlycten of the conjunctiva will extend over the cornea.

The process may begin as a very peripheral phlycten of the limbus, with the formation of a regular leash of blood-vessels, as we are apt to see it in phlyctenular conjunctivitis. As soon as the ulcer has formed, it will spread and travel over the cornea towards the centre, carrying with it this fascicle of blood-vessels which lie upon the tract made by the advancing ulcer. This has been called a *fascicular keratitis.* The ulceration seldom goes beyond the corneal centre, and may stop before it reaches it, the blood-vessels dwindling down and disappearing, leave a band-shaped opacity in the cornea, which, however, will entirely disappear, as the ulceration seldom extends as deep as Bowman's membrane. They are generally solitary, but more than one may attack the cornea at the same time. They are apt to recur, but not more so than any other phlyctenular ulcer. They differ from pannus by a peculiar leash-like arrangement of the vessels which do not lie upon the cornea but in the epithelial layer of it, and from a diffuse keratitis, that the blood-vessels of this form of keratitis are scattered all over the cornea, and do not form a fascicle of vessels.

Another variety of marginal ulceration will extend rapidly to the deeper layers of the cornea and lead to a small perforation and a prolapse of the iris. This is very apt to be found in very debilitated children, especially after whooping cough, but it is not often met with.

This disease is found under the same circumstances as conjunctival phlyctens (see page 106), and its symptoms are very similar to those of this trouble, except that they are more severe; this is especially the case in regard to the pain. The child is restless all day and sleepless at nights, crying and fretting all the time. The photophobia is also more marked, and the blepharospasm so intense, that the whole side of the face is twisted and distorted, and it is hard work to open the eye—the use of lid retractor may in fact be needed to expose the cornea to its full extent. In order to overcome the blepharospasm, it may be necessary to plunge the face of the child into cold water, which will relieve the spasm temporarily and enable us to finish our examination. The tears are very abundant and very sharp, causing generally excoriations and fissures of the lids, which will make it more painful to again open the eye and cause even profuse bleeding, if the lids are opened forcibly. The nose will likewise become affected, and the margins of the nostrils are apt to become very sore and eczematous and covered with a thick, heavy crust. The photophobia is very marked even in very small ulcerations; the child cannot be made to look up, and is constantly burying its face in the mother's arms. The patient prefers to stay in bed, burying its head in the pillow till noon, The symptoms will abate somewhat in the evening, to become very bad again towards morning.

The disease is frequently accompanied by localized blepharadenitis, fissures of the outer canthus, eczema of the lids and face, coryza, especially of that side of the nose corresponding to the affected eye; conjunctival symptoms, due to direct extension of the inflammatory action or to bad medication are often quite marked.

In long continued cases the conjunctiva may become so thickened and inflamed that the diagnosis between this and a chronic blennorrhœic process may become very difficult. The condition of the patient in the morning and evening may help us in such cases to come to a correct diagnosis of the case.

The œdema of the lids is generally due to the blepharospasm, the veins of the lids being pressed upon by the closed lids as they turn at the free edge of the lid into the deeper structures.

Treatment.—As the disease affects generally children at the period of dentition, or at the age of puberty, and especially those of a strumous diathesis or otherwise in a bad state of health, the hygienic and dietetic part of the treatment is of great importance. Place such children, if possible, under favorable surroundings, give them warm, dry, airy rooms of uniform temperature, let them have a warm bath, if possible a warm salt-water bath, several times a week, regulate their diet so that they get only three meals a day, consisting especially of meat, eggs, fruit and easily digested food. Do not let them live on potatoes, bread, and other starchy food exclusively, as they are apt to do. Nothing should be taken between meal-times, nor late at night; give the patient's stomach a chance to rest and recuperate, so that with a renewed activity of digestion, the nutrition becomes more active.

The eyes should be protected against bright lights, by blue glasses or large shades protecting both eyes, but tight bandaging of the eye should be avoided. In the acute stage of the disease all irritants should be avoided. The great remedy that we have to rely upon is atropia, this should be administered in very mild solutions, say a two-grain solution for larger children, and a half to a one grain solution for smaller children. These mild solutions should be instilled frequently, until the full dilation of the pupil indicates that the atropine has been absorbed. Often it is sufficient to apply it only twice a day, in order to keep the pupil fully dilated. The greatest difficulty will be experienced in getting the parents to apply the atropine properly.

The blepharospasm makes it difficult to open the eye of the child, and if this is partly accomplished, the lachrymation is so great that the atropia is washed out of the eye before it becomes absorbed, and consequently can do no good. The blepharospasm may be relieved by immersing the child's face suddenly in cold water, or by letting ice-water drop on the cornea. After this the atropia may be used.

The physician should make it a point to apply the atropine himself and repeat the application at intervals of ten minutes until the atropine begins to dilate the pupil. After this the photophobia and the other symptoms will be relieved to such an extent by the anodyne effect of atropine, that further applications are much easier. I have to mention here once more, that some children are so easily affected by atropine, that one application will produce erythema of the face and the body, with marked febrile symptoms. Unfortunately duboisine, the principal substitute of atropine, is even a more energetic poison.

The only safe way is to use only a very mild solution in such cases. The use of warm water or poppy fomentations will not only comfort the patient but facilitate the absorption of the atropine, by reducing the intraocular tension of the anterior chamber; these applications should be used about three times a day. After the subsidence of the more acute inflammatory action, the use of Pagenstecher's ointment, see page 110, with or without the addition of atropia, will hasten the cure. But generally the milder action of the calomel will be all that is required. It should be used in very small quantities dusted into the eye, but it should not be used as long as the acute inflammatory symptoms are present, especially when the ciliary injection is very marked. An attack of this kind may last for a few days, but if the disease becomes chronic it may last for many months, getting at times a little better, but after the slightest exposure returns with new force. In such cases calomel or the red oxide of mercury ointment may be used more freely. Iodoform in powder dusted into the eye, or better mixed with a little vaseline and atropine, see page 139, may be used.

The general condition requires in these cases great attention. Tonics of iron and Peruvian bark, change of air, and in scrofulous children the use of cod-liver oil are indicated. In very obstinate cases the use of a seton applied to the temples acts well; this is applied by pinching up a fold of skin and drawing a very thick thread of white silk through it.

It is to be left there, and moved daily for several weeks till the eyes are well or till it ceases to discharge. By grasping a fold of skin and drawing it away from the head, the wounding of the temporal arteries is avoided; if this should occur, however, by withdrawing the needle and by gentle pressure, the hemorrhage is easily checked, when another spot may be selected. If signs of erysipelatous inflammation should be seen, which will show itself in very rare cases, generally on the first or second day, the silk must be withdrawn at once and a mild preparation of sugar of lead and opium wash applied. The best place for the application of a seton is under the hair, a little above and in front of the ear, as in this case no scar will be visible after removal of the seton. The disease seems to be created and kept up by a poor condition of the blood, which in such children contains a large number of white blood corpuscles. Their preponderance over the red corpuscles will be diminished by the improved hygienic conditions, and to a certain extent by the drainage from the seton, which will also improve the local parts by freeing them from an abundance of the so-called wandering cells. Another form of counter irritation, the use of a blister behind the ears, will do good in some of the chronic forms of this disease, and in former times enjoyed great reputation. The complications of this disease, conjunctival as well as those of the lids, should be attended to after the subsidence of the acute inflammation.

3. *Keratitis Diffusa, Interstitial, or Parenchymatous Keratitis.*—We have to consider two forms of this disease, the one characterized by a general diffuse infiltration, without the formation of vessels in the cornea proper, the other characterized by great vascularity of the cornea. They are both to be looked upon as local expressions of a constitutional trouble. Simple interstitial keratitis is characterized by a deep uniform infiltration of the corneal tissue proper without changes of the elastic laminæ and only slight changes of the epithelial layers. It is principally caused by a proliferation of the corneal cells resulting in slight swelling and diffuse cloudiness of the cornea. The cloudiness begins generally on one side of the cornea as a thin, hazy film, which, advancing slowly over the whole of the cornea, becomes more opaque; but this may vary considerably in different parts of the cornea, from a slight haziness to a dense whitish opacity, and even yellowish patches may be seen. The extreme margin of the cornea remains generally unaffected and appears quite clear. When the inflammation is at its height, the whole cornea appears so opaque, that the iris is almost entirely hidden. The epithe-

lial layer at this period presents a fine granular appearance, as if the cornea had been pricked with a fine needle. The process of infiltration is preceded by an increased sensitiveness of the eye, slight photophobia is complained of and very soon with the first signs of infiltration the ciliary vessels become injected. The ciliary injection is nearly always marked in the disease, varying of course according to the intensity of the inflammation. The conjunctival injection is generally not marked, and therefore the contrast is an especially striking one.

The ciliary injection will become very intense if the eye is exposed to the light or other irritating agents, and the eye flushes up very much even during an examination. Lachrymation is not a marked symptom, but is present during acute attacks of pain and on the admission of light to the eye; pain is not a prominent symptom, it is present only in few cases, especially in those that are complicated with iritis.

As the cause of the disease is generally constitutional, both eyes are apt to become affected, either at the same time, or oftener one after the other. The disease appears most frequently in persons afflicted with inherited syphilis, so that it has been called a specific keratitis; but this name should be reserved for those cases where the inflammation is one of the secondary manifestations of acquired syphilis: it will occur also in scrofulous patients or badly nourished children. If the disease is due to hereditary syphilis, we will find other peculiarities in the formation of the bones indicating the source of the trouble. A child with congenital syphilis has peculiarly notched teeth, especially do the upper incisors show one or more notches; they are more pointed and are called Hutchinson's teeth. It is only in the permanent teeth that we notice this formation; earlier symptoms are scarcity of hair, which is thin and soft; the forehead is large, square (almost hydrocephaloid, Dr. R. W. Taylor), the roof of the mouth is very highly arched, and the bridge of the nose is broad and sunken in; especially in these cases there is generally much coryza. Such patients have a peculiar pallor and a loose, soft skin; but also, apparently healthy children will suffer at times from the disease. The age of the patient is generally between the sixth and twelfth year, but it may also be found at the age of puberty, and in some cases the disease will make its appearance as late as in the twenty-fifth or thirtieth year.

The disease may at times be very severe, but it is always a very tedious and obstinate trouble. Ulcerations of the cornea do not often take place. You may safely tell your patients friends that a disease of this kind will last many months or even more than one year; but you may assure them at the same time, that complete recovery is only a question of time, that the infiltration material will be absorbed again, leaving the cornea quite clear, or only a little hazy, which, however, will not show except under oblique illumination.

Of frequent occurrence is an extension of the process to the iris and in a few cases even to the choroid. In such cases our prognosis ought to be more guarded, as the result of such cases may be great impairment of sight. In these cases the pains as well as lachrymation and photophobia, as well as the ciliary injection are more marked.

Treatment.—The antisyphilitic treatment in those cases that are due to inherited syphilis is of the greatest importance. Small doses of hydrargyrum will not only have a beneficial effect on the keratitis, but may change the whole appearance of the child in a short time. If it can be done carefully by the mother, the inunction treatment is perhaps the best; ten to twenty grains of the gray mercurial salve should be rubbed into the soles of the feet at nights, alternating with the feet, applying it one night to the one and the next night to the other foot, in order to avoid the appearance of an eruption at these places. Of great help are also small doses of calomel, say half a grain three times a day, or the hydrargyrum cum creta, one grain combined with two grains of aromatic powder, three times a day. In severe cases the mixed treatment may be tried: ℞. Hydrarg. biniodidi, gr. ss; pot. iodidi, ʒ ij; syr. aurantii et aquæ, āā ℥ iij. S.—A teaspoonful twice or three times a day for a child ten years old. In the scrofulous variety, iodide of potassium in three to five-grain doses three times a day, or the syrup of the iodide of iron, five to fifteen drops after meals in water, should be given. Cod-liver oil may be given in all cases, when the want of nutrition seems to call for it. A good meat diet is best suited for these children, and an occasional sea-water bath or a sponge bath with diluted alcohol is of great service. Jaborandi has been recommended highly, ʒj in infusion to be taken during the day, and to be continued for several weeks.

Of local remedies alone little can be expected to cut short the duration of the disease; but the indications are: to protect the eye, to keep off all irritation, and to obtain perfect rest for it. Use therefore atropine, a one-grain solution, two drops three times a day. This is to be increased if the disease becomes complicated with iritis. The use of blue glasses and keeping the patient in a dark, but well-ventilated room, are also necessary. In order to hasten the absorption of the infiltration, make warm applications of either plain warm water or an infusion of chamomile flowers, as warm as the patient can bear it, three times a day, for an hour or two at a time. This will cause increased vascularity and hasten the clearing up process. This may also be done by judicious insufflations of calomel every other day, during the latter part of the disease.

In some of these cases we have the most intense photophobia with blepharospasm, lachrymation and severe pain. The child is not able to open its eyes, and does not leave the dark room. In these cases the eyes should be opened forcibly, and kept open for some time. Atropia should be used freely; but it will at times give no relief, because it is not absorbed, even not after the hot-water bath; the steam bath may also fail to relieve the pain and photophobia. In these cases ice-water dropped directly on the cornea for a few minutes frequently during the day has been very useful. Not only is the pain greatly relieved, but also the photophobia is much improved by it. In cases complicated with iritis it should not be continued for any length of time.

4. *Keratitis diffusa vascularis.*—We have two varieties of vascular diseases of the cornea, the one is characterized by the formation of a leash of vessels, the fascicular keratitis; the other has numerous small vessels running through the whole cornea: this disease is almost identical with the other form of diffuse keratitis in its course, duration, symptoms and prognosis. The beginning is like that of the non-vascular variety, the cornea becomes infiltrated, hazy. After, or in a few cases before the beginning of a ciliary injection, small blood-vessels are seen running from the periphery of the cornea to the infiltration. These vessels are probably not only derived directly from the marginal ciliary vessels, but also by the formation of new blood-vessels in the cornea; very soon their number increases and they will expand in all directions, so that the whole cornea looks reddish, and eventually it may assume a fleshy look. The epithelium looks loosened and implicated, but it will seldom break down into ulceration. As the case progresses, the blood-vessels become fewer in number, the infiltration disappears, and soon all traces of the whole process have disappeared; at other times slight corneal opacities remain for some time.

The disease might be taken for pannus, but in pannus the cornea is thickened and rough and the blood-vessels lie on the surface of the cornea, and are derived directly from the conjunctiva running over the limbus. In vascular keratitis, on the other hand, the vessels dip under the limbus, the surface of the cornea is smooth; and the condition of the conjunctiva, which is the cause of pannus (trachomatous processes and trichiasis), will likewise help to make a diagnosis.

Vascular keratitis is of more frequent occurrence between the ages of ten and twenty years, it seems to affect scrofulous people especially. Females are sometimes affected with it at the age of puberty. Complications, such as iritis or irido-choroiditis, are not often met with in this form of the disease, and the prognosis is therefore more favorable; the slight remaining opacities will eventually disappear entirely, but the duration of this affliction will be almost as tedious as that of the first variety.

The treatment is like that of the simple diffuse keratitis. Hygienic measures, good food, warm moist applications and atropine three or four times a day, and blue coquilles should also be used. The stimulating use of the calomel may be begun with earlier than in the diffuse variety.

Of the greatest importance in this trouble is the administration of iodine, especially the iodide of iron in the shape of the syrup or as iodide of iron pills, which for ladies are preferable, because they will not stain the teeth. Cod-liver oil is also indicated, and of great value are tonics, especially rhubarb and Peruvian bark. ℞. Tinct. rhei. comp. ℥ ij; tinct. cinchon. comp. ℥ i. M. S.—ʒ ij in water before meals.

5. *Keratitis traumatica.*—Inflammatory actions of the cornea may be caused by injury or by the presence of foreign bodies. The cornea will heal readily after any injury causing a clean cut wound, but bruises and abrasions are not apt to heal promptly, and may result in dense opacities.

The most dangerous of all injuries, however, is a burn caused by chemicals, and especially burns by lime are very destructive. Wounds of the cornea, caused either accidently or by operation, heal as a rule favorably, especially in young persons, leaving hardly any traces, but they are more dangerous if they are perforating and if the iris becomes implicated, preventing the close apposition of the edges of the wound. In persons of a low state of health or in badly nourished patients, ulcerative action may set in, causing more or less destruction of the cornea. Abrasions are generally caused by a slight scratch, for instance by a branch of a tree or by a baby's nail. They may be very slight, calling hardly for any treatment, as they cause no pain or inconvenience to the patient; but if the wound is deeper, it will, as a rule, become painful and cause intense photophobia and lachrymation. They will generally heal in a short time and yet, if neglected, they may result in very serious lesions. By the constant action of the lids, by the irritating effects of the light or by exposure, a small injury may become the starting-point of a dangerous slough of the cornea. This is especially the case in nursing mothers, or if the presence of a small foreign body should complicate the abrasion and keep up the irritation. On examining the surface of the cornea very carefully by oblique illumination, we shall be able to distinguish the abrasion as a glistening spot, slightly depressed by the loss of epithelial cells; there is more or less ciliary injection and photobia, which make it sometimes difficult to examine the patient.

Contusions of the cornea are not so often met with, because the lids will close quickly and protect the cornea; they are generally caused by flat bodies flying against the cornea. A rupture of the cornea is seldom produced by such an accident; the cornea is bruised, but the force of the blow is transmitted to the sclera, which is often ruptured. The bruised portion of the cornea will soon become hazy, and in unfavorable cases may break down and slough, causing often entire loss of the eye. The symptoms are very marked under these circumstances, there is intense pain, profuse lachrymation, marked photobia, and the injection affects not only the ciliary vessels, but also the whole conjunctival vessels.

If a foreign body, *corpus alienum*, reaches the cornea and becomes imbedded in it, it will cause at once great inconvenience and pain, and especially if it be, as it happens very frequently, a hot cinder, producing at the same time a burn of the cornea. Smaller bodies, like particles of steel or dust, may remain on the surface, of the cornea for some time, causing hardly any unpleasant symptoms, except those of slight photophobia and lachrymation, especially if the patient's eye becomes irritated by light, or if he attempts to use it. Larger and rough substances are, however, very troublesome, because every motion of the lid will not only disturb them, but force them deeper into the corneal tissue. There is soon marked ciliary injection around the cornea, and the pupil will be narrower than that of the other eye. On light eyes with a blue iris, the presence of a foreign body is easily discovered, but in dark eyes it may at times escape superficial examination. In looking for a foreign body, use oblique illumination, or observe the reflex of a window on the cornea. Of great danger, and at the same time hard to discover, are the transparent husks of wheat or grass-seeds, that will sometimes get into an eye. In old people, they are apt to be the cause of a very obstinate and destructive ulceration of the cornea. Injuries or burns of the cornea may be caused by acids, caustics, strong alkalies, or by a flame. In these cases the prognosis is always bad; it is generally difficult to remove the causes of the injury rapidly enough to prevent extensive injury to the cornea. The most dangerous of all these substances is lime. At the first examination nothing but a very shining portion of the cornea will indicate the seat of the injury, but in the course of time more and more of the corneal tissue will become cloudy, and it may be only after weeks that the whole extent of the injury becomes visible. At other times the injury may cause cloudiness of the cornea very rapidly, which will sometimes clear up again; this is especially the case in more superficial burns caused by the light of a candle or by milder acids, like carbolic or chrysophanic acid; stronger acids, like sulphuric or nitric acid, will produce deeper lesions. Burns of the cornea are very painful, causing great photophobia and lachrymation. In such injuries the conjunctiva will suffer more or less at the same time; they are therefore accompanied by great redness of the eye, so that the ciliary injection may be hidden under the inflamed conjunctiva. Deep burns will frequently cause inflammation of the iris and ciliary body and often implicate the lens primarily, causing traumatic cataract; this may, however, appear later as a result of the disturbed nutrition due to the injury of the ciliary body. Dense opacities of the cornea, and more or less destruction of the sight, must therefore be expected as ultimate results of such injuries.

Treatment.—In traumatic keratitis, no matter what it is caused by, rest and cold water applications are indicated. Clean wounds of the cornea heal by first intention rapidly, with only slight opacities. In irregular wounds, if they are caused by laceration, where a close apposition of the edges of the wound cannot be obtained, the process is more tedious. In perforating wounds the main object is to prevent a prolapse of the iris, or if this has occurred already, to restore the iris to its normal position. According to the location of the injury, whether central or peripheral, the use of atropine or eserine is indicated. In prolapse of the iris, if recent, we may attempt to replace the iris by gentle rubbing of the wound by means of a little horn spoon, or by removing it from the wound with a small spatula, or by rubbing the lids of the wounded eye with the finger, or by the use of atropine or eserine, which will draw the iris away from the wound and keep it in place until the wound has closed and the aqueous humor formed again.

In larger wounds the prolapsing portion of the iris may be seized with forceps, gently drawn out of the wound and abcised closely to the margin of the corneal wound. After this has been done, atropine and a pressure bandage should be used.

Abrasions of the cornea require especially rest and protection from the irritating effect of light on the denuded nerve fibres. The treatment should therefore consist in the use of a few drops of atropine, and the application of a firm pressure bandage, which will prevent all motion of the lids. In severer cases it will be well to bandage both eyes, so as to control all movements of the eye itself. The bandage may be removed once every twenty-four hours, and oftener if there should be much conjunctival irritation, accompanied by a discharge. Under this treatment abrasions will heal in one or two days.

Foreign bodies should be removed as early as possible, as their presence might lead to ulcerations of the cornea. If they are superficial, this may be done by a soft piece of wood or a piece of paper, or by a little cotton wrapper wound around a match, but if they have been in the eye for some time, or are imbedded in the cornea, a spud or a cataract needle should be employed for this purpose. If you attempt the removal of a foreign body, sit in front of the patient or stand behind him, resting his head on your left arm, let him fix an object in such a way, that the foreign body is easily seen, and steady his eye by pressure of your finger on the upper and lower lid. Should the patient be unable to control his eye, you may introduce an eye speculum and steady the eye by grasping a fold of the conjunctiva immediately under the cornea by means of a pair of fixation forceps; if necessary give ether. If a foreign body has passed through Bowman's membrane into the deeper tissues of the cornea, it will become necessary to dig it out by the use of a sharp cataract needle. Great care must be used in such cases not to push it into the anterior chamber; if the foreign body is lodged in the membrane of Descemet this will be difficult to prevent. In such cases a broad needle may be introduced into the anterior chamber under the foreign body, to prevent it from falling into the anterior chamber, while another needle is employed to remove it. Under these circumstances, and often in comparatively superficial bodies, if the patient is very excited and nervous, the administration of ether becomes necessary. If the foreign body is not removed, it may become surrounded by a zone of infiltration, set up ulceration, and may be gradually loosened by the breaking down of the surrounding tissue and is thrown off with the discharge. Such ulcers heal up, generally leaving only a small macula of the cornea, but they may lead to deeper inflammations causing the loss of the eye. Smaller foreign bodies like grains of powder may become encysted and remain in the cornea without setting up any irritation. They may look like pigment; they must not be mistaken for it, as pigment, visible to the eye, is never found in the cornea, except after prolapse of the iris and the formation of an anterior synechia.

Burns of the cornea, especially if caused by lime, require the most careful removal of the smallest traces of the injurious substance. In recent cases we may try to neutralize the injuring substance, by a solution of the bicarbonate of soda in the case of acids, or by diluted vinegar or lemon juice in case of alkalies. Lime is most apt to get into the eye in the shape of mortar; it is therefore necessary to remove carefully even the smallest grains of this, by washing it with very diluted vinegar, one part to four of water, and picking it out by means of a spud. After this, it becomes necessary to use atropine, and in order to avoid the formation of adhesions of the burnt cornea and the burnt conjunctiva of the lids, the use of castor oil is indicated. ℞. Atropiæ sulph. gr. ss; ol. ricini, ℥ ss. Misce exactissime, S.—Shake well and put one drop into the eye every half hour. Cold compresses should also be used.

6. *Keratitis neuro-paralytica.*—In the normal state of health, any small particle of dust that will get on the cornea will by reflex irritation cause at once a movement of the lids and lachrymation, by which the irritating body will be removed from the cornea. If the superior branches of the fifth nerve, however, become paralyzed, either from central lesions or from injuries or operations on the nerve, this reflex action of the nerve is not possible, on account of the anæsthetic condition of the sensory filaments of the ciliary nerves, and the movements of the eyelids become sluggish, because there is no demand for their action. Any foreign body or fine particles of dust may now rest on the cornea for a long time before they are removed by the action of the lid. The tear fluid is in such cases less abundant than in the normal condition, and on account of the slow action of the lids

the fluid in which the cornea is bathed evaporates, the epithelial cells become dry and are loosened.

The dust or other foreign substances, that get on the cornea under such circumstances, are apt to cause suppuration, and on account of the want of nutrition of the cornea, it is apt under these circumstances to slough away entirely. Very extensive ulcerative changes with more or less destruction of the cornea will be the result. The prognosis is therefore a very bad one, and as no treatment can do much good, the greatest care should be taken to prevent this disease. In a case of paralysis of the fifth nerve, the patient should be instructed to close the lids of the affected side as often as possible, and as soon as the slightest cloudiness of the cornea is noticed, a few drops of a weak solution of atropine should be dropped into the eye; the eye itself should be thoroughly cleaned of dust and mucus, and the lids closed by means of strips of adhesive plaster. This should be renewed once a day in order to allow inspection of the eye; a mild galvanic current may be applied to the closed eyelids daily. Another and perhaps safer plan is to sew the eyelids together after paring the edges, and to allow them to heal together. After the paralysis of the fifth nerve has disappeared the eye may be opened again.

7. Keratitis bullosa—Pemphigus of the Cornea.—This is one of the rarer diseases of the cornea, affecting in the majority of cases eyes that have suffered in consequence of local diseases, such as glaucoma or choroiditis; it will also occur in patients whose health has suffered by old age or malarial fevers. It is a very chronic affection, characterized by the periodical appearance of a large vesicle on the surface of the cornea. The bulla, which is caused by a thin serous fluid lifting up the epithelial layer, will rupture easily and the fluid contents will escape, leaving a superficial excoriation of the cornea. These attacks may occur every three or four days, or only once a week. There is always a period of rest between the attacks, in which the patient is free from pain, the eye almost free from irritation, and in which the cornea shows only slight opacities. The formation of a new vesicle is preceded by intense pain, great injection, photophobia and lachrymation, and a more or less marked febrile state, confining the patient to his bed; the pain and other symptoms remain quite severe till the bulla has ruptured. These attacks may recur for years with the same regularity; sometimes there are longer intervals of rest. There is in some cases a slight increase of tension in the eye just before and during the attack, and more or less anæsthesia of the cornea.

Treatment.—The treatment has so far been very unsatisfactory. Atropia will give relief in some instances and quinine and anti-malarial remedies, especially Fowler's solution of arsenic, have done some good, but a cure of the disease has never been accomplished by these remedies. Iridectomy and paracentesis of the cornea have likewise failed to effect a cure. During the acute attacks of the disease, morphia, gr. ¼, may be given hourly till the pain is relieved. The general health of the patient may require a tonic treatment, which is about as effectual as anything. The disease will eventually become less severe and the intervals between the attacks longer.

8. *Keratitis specifica.*—Among the rarer secondary manifestations of syphilis we have also a diffuse interstitial infiltration of the cornea. This attack of the cornea is generally one of the later secondary manifestations of syphilis, like iritis, but it may occur also quite early, simultaneously with the roseola or affections of the throat. It generally occurs as a primary affection, but in some cases it will follow or accompany specific iritis. Both eyes may become affected, but this is by no means the rule. The infiltration in this disease takes place after a short premonitory stage, accompanied by lachrymation and slight hyperæmia of the ciliary vessels. A faint cloudiness will now gradually extend over a large part of the cornea, but it will seldom develop to such an extent as we see it in hereditary syphilis. It may occur together with specific iritis.

The infiltration forms in cloud like spots, varying in intensity and enclosing patches of almost clear corneal tissue; in milder cases the infiltration appears localized in a few spots only. The disease will increase in intensity for one or two weeks, and then disappear rather suddenly, especially after the use of mercurials.

The process of repair will generally result in perfect clearing up; sometimes faint corneal opacities will be left, which, however, do not interfere with vision to any extent.

Symptoms.—There is always marked ciliary injection, but hardly any photophobia. The patient is able to face even sunlight without much inconvenience; the lachrymation is only moderate and only by irritation will it become more marked. The pain is very characteristic; it is almost entirely absent during the day, but it will become severe at night, especially between one and three o'clock in the morning.

Treatment.—The best plan of treatment is mercury in some shape; the mercurial inunctions are especially very beneficial. A mercurial bath gives prompt relief. Atropia should be given freely, and warm water compresses are to be used often during the day.

9. *Keratitis suppurativa* (Fig. xv.)—The principal feature of suppurative keratitis is the accumulation of the infiltrated cells at one portion of the cornea to such an extent, that it will cause the breaking down of the part affected. It will therefore lead to the formation of an abscess or an ulceration.

This disease is divided into the subacute and acute variety, although clinically such a division is practically impossible, because the symptoms vary to a great extent. The trouble is acute, if it is of a sthenic character, or if the symptoms, pain, photophobia and congestion are great. The subacute variety differs from this form of the disease by the absence or mildness of the inflammatory symptoms, not even pain may be experienced. But it is nevertheless a very dangerous affection, as the whole cornea may slough in a short time, sometimes within twenty-four hours, before the patient is fairly aware of the fact that there is any trouble with his eye. It will affect persons that are greatly reduced in health by starvation or imprisonment; it is also apt to occur in patients suffering with greatly debilitating diseases, such as phthisis, typhus or cholera and small pox. It occurs also in weak, delicate children.

The beginning of the disease is so insignificant that it will often escape attention; there is hardly any congestion of the eye, but a small degree of photophobia may induce the patient to keep his eye shut. When these are opened, he may find himself almost blind in one eye on account of profuse infiltration of the cornea. The infiltration begins as one or more yellowish spots, these will rapidly coalesce and form a deep ulcer, involving a large portion of the cornea. The process may stop here, and after some time the margin of the ulcer may clear up, the ulcer itself get smaller and cicatricial tissue may form. This may, if central, cause great impairment of vision. Very often the ulcer will perforate through Descemet's membrane, pus will accumulate in the anterior chamber, often in considerable quantity (Fig. xv.), the iris will prolapse and unite to the corneal wound, resulting in a leucoma adherens. In very bad cases the inflammatory action may extend to the deeper tissues of the eye, destroying it entirely.

Acute suppurative keratitis is a very different type of the disease. Here we have great pain not only limited to the eye, but extending along the nose, the forehead, and even to the back of the head. The eyelids are tightly closed and the photophobia is so great, that it is only with the greatest effort that we can examine the eye; this is especially the case in extensive superficial ulcerations: in deeper ulcerations there is of course also photophobia, but it is not so marked. On opening the eye an abundance of hot tears will escape; the patient will also complain of the profuse lachrymation; the congestion is not confined to the ciliary vessels, the conjunctiva is often so congested and roughened, that it may be hard to decide whether the conjunctival affection preceded that of the cornea or not. There is also marked chemosis in some cases. The main feature of the disease is the formation of an ulcer; this is sometimes preceded by the formation of an abscess, but generally the process begins as a superficial infiltration, resulting in a very short time in an ulceration. These superficial ulcers give, as a rule, a more favorable prognosis; the loss of substance is not so great, and it may fill up readily, causing only slight changes of the cornea. Sometimes they will extend also to the deeper tissues. All those ulcerations are generally accompanied by pus in the anterior chamber (*hypopion, hypopion keratitis*).

This may rapidly fill up half or more of the anterior chamber and will often disappear as rapidly as it came; in other cases new pus is poured out before the rest of the old pus is entirely absorbed. This may continue as long as the ulcerative process lasts. The pus will in many cases not be able to penetrate Descemet's membrane and become scattered through the rest of [redacted] centre of the cornea as a superficial, ditch-like ulceration with nearly circular outlines. The peculiarity of it is the marginal infiltration which surrounds the ulcer on all sides like a faint cloud. This infiltration will spread on one side, and as it spreads, the innermost portion will break down, and thus the ulcer will travel all over the cornea, leaving a faint opacity in its trail; the ulcer may also travel backwards again over the same ground it travelled over before. It is not very deep, as a rule, and will seldom cause perforation, but it will leave the cornea quite opaque, and as it generally occurs in old debilitated persons, it is not apt to clear up sufficiently to give the patient much sight. It is not only tedious, but also very painful, accompanied often with the formation of hypopion, intense injection and chemosis of the conjunctiva and œdema of the lids, and also frequently by plastic iritis.

The prognosis of suppuration of the cornea is not good; it depends on the seat, the extent and depth of the ulcer. Loss of substance of the corneal tissue is not covered by drawing the surrounding tissues into it, as this occurs in the skin, or conjunctiva, it has to be filled up by new tissue; this may be done only partly by a layer of epithelial cells spreading over the ulcer, which in such a case leaves a clear depression in the cornea; this is a *facet*. But generally this loss of substance is made up by the formation of a dense fibrous tissue, which becomes covered with epithelial cells; this tissue, however, is not transparent, but causes an opacity of the cornea. A central ulceration, even if small and superficial and leaving only a slight macula corneæ may interfere more with the vision of the patient than a deep extensive peripheral ulceration causing a dense leucoma, because the first opacity is in the line of vision and the latter is not. Perforating ulcers will always increase the danger, not only to the sight of the patient, but the deeper structures of the eye may become diseased in consequence of it. If the iris and lens prolapse, the sight of the patient is generally lost, because the lens will become eventually opaque (*cataract*). We have further seen that staphylomatous bulgings of the cornea will occur. Another complication we meet with after a perforation, is a *corneal fistula;* it is caused by repeated perforations disturbing the healing of the tissues, or by the fact that the prolapsing iris did not fill up the perforation completely.

The principals for the *treatment* of suppurative keratitis are those indicated in the beginning of this chapter. An abscess of the cornea or a beginning ulceration must be treated with atropine, in such doses as to cause a full dilatation of the pupil. The use of hot applications is also indicated: warm water, and in very painful affections, warm poppy-fomentations are good, and even cataplasms may be used. These warm applications may be used in the beginning only three or four times a day, for one hour each time, but if the process is more extensive, the applications should be continued the entire day. As the discharge of the ulcer, and especially that of the conjunctiva, if the process is associated with this trouble, is septic and irritating, it should be very often removed and neutralized. This is accomplished by the use of a solution of boracic acid, ten grains to one ounce of water, or by the use of chlorine water, one part to four parts of water: this should be dropped into the eye every hour, a few drops at a time. Antiphlogistic treatment is not only indicated in cases accompanying blennorrhœic processes of the conjunctiva, but even in those cases where the injection is extensive, the ice applications may have to be omitted for one hour mornings and evenings, and during this time, hot water applications may be used, with the best results in regard to the ulcerative action of the cornea. Great pain is to be relieved by the use of morphia in the shape of hypodermic injections, or the use of chloral or bromide of potassium may be necessary, especially for the night. In large, extensive suppuration of the cornea great improvement in the healing process is obtained by the use of large doses of the sulphate of quinine. It may be given in ten-grain doses three times a day for several days, and later five grains of it, twice or three times a day, should be given to improve the general condition of the patient.

The *treatment* of chronic ulcerations of the cornea as well as those that are accompanied by great thickening of the conjunctiva, may require however a more energetic stimulating treatment. The best remedy in our possession for this purpose is nitrate of silver. It may be used in the stick, to touch the margin of the ulcer with; this has to be done very carefully once every two or three days, taking care not to injure the healthy corneal tissue. If this is done carefully it is not necessary to wash it off, but if it has been applied too liberally, it should be neutralized with a mild solution of common salt, and washed off by means of a camel's-hair pencil with pure water. A very valuable remedy for this condition of chronic suppuration is the use of the pulverized iodoform; it is to be dusted into the ulcer once every other day. It acts as a local anodyne, as a good antiseptic and is a powerful stimulant.

Of excellent service in such cases, if they occur in lymphatic persons with a pale doughy complexion and enlargement of glands, is the application of a seton to the temple of the affected side (see page 123). The seton in these cases should include at least one inch of the skin, and must be inserted quite deep. It may remain in place in some of these cases as long as one or two months.

If there is much thickening and roughness of the conjunctiva, which may keep up a continued irritation of the cornea, it is well to touch the conjunctiva once a day with a five-grain solution of nitrate of silver. Sometimes this conjunctival irritation is kept up by the long continued use of atropia. In these cases a slight touching of the surface of the conjunctiva by means of a piece of alum once a day will greatly relieve this condition. In other severer cases the atropine may have to be discontinued and another mydriatic, like duboisine, may be used instead.

(1.) Surgical interference is indicated when the process extends rapidly to the deeper layers of the cornea, threatening perforation or implication of the whole of the corneal tissue. In such cases it is of great importance to decrease the intraocular tension; this is most conveniently effected by a paracentesis of the cornea. After the paracentesis is made, withdraw your knife slowly, pressing at the same time very gently on the lower margin of the wound. The aqueous humor will flow off slowly and thus prevent a prolapse of the iris. If the ulcer is extending rapidly, but more in circumference than in depth, a paracentesis should be made and it may be done independent of the seat of the ulceration. It is best performed with a broad cataract needle or with a cataract, knife by making an oblique puncture at the outer or lower margin of the cornea. The greatest care should be taken to avoid the wounding of the iris and lens, and to prevent a prolapse of the iris. This is avoided by making the puncture of the cornea not straight through the tissue, but by giving the incision an oblique direction. Another point is to make the incision in such a place that a possible scar from it will not lie in the line of vision; care must be taken not to split the cornea by holding the knife too obliquely. The operation is not very painful and may be done without ether. It must not be forgotten that the cornea offers much resistance to the knife, and that after the knife has penetrated the cornea, it is apt to be pushed deep into the anterior chamber, causing sometimes a wound of the lens or iris. The eyeball should therefore be fixed by means of a pair of forceps, applied at a point opposite to the point of entrance, or if this is impossible, as near to it as possible. The knife should be held firmly, which will give us a better control over it, and the point of it should be perfectly smooth and sharp.

(2.) In hypopion, if there is no perforating ulcer, the hypopion occupying, however, more than half of the anterior chamber, and if the pain and inflammatory symptoms are severe, a paracentesis should be made in the lower portion of the cornea. Great care should be taken to evacuate as much of the pus as possible. The purulent matter filling the anterior chamber, may be thick and of a fibrous nature and not flow out with the aqueous humor; it may therefore become necessary to remove it by means of a delicate pair of iris forceps.

(3.) In cases of deep ulcerations, having penetrated nearly the whole thickness of the cornea, an incision should be made through the ulceration and as nearly as possible across the centre of the cornea (Noyes), because in this location there is less danger of a prolapse of the iris than in a more peripheral one. The removal of the purulent mass from the anterior chamber will be very difficult at times.

(4.) Paracentesis should be made in cases of deep ulcerations, when the bottom of the ulcer becomes bulging on account of the *vis a tergo*. In these cases perforation will take place early, and may lead to staphylomatous changes of the cornea (Fig xvi.) The paracentesis should in these cases be made with a fine cataract needle and only at the bulging portion of the ulcer. After a paracentesis the eye should be brought under the influence of eserine. A few drops of a solution of two grains of eserine to one ounce of water should be instilled into the eye and a firm compress bandage applied. It is best to wash out the conjunctival sac with a solution of boracic acid; after this, put the eserine into the eye, and place immediately a piece of linen, smeared thickly with vaseline, over the closed lids; on top of this some borated cotton and over this the bandage, which should be made of flannel in winter and thin gauze in summer. The bandage is to be changed at least twice a day and the eserine is to be continued until a firm cicatrix has formed. An iridectomy has been recommended for the same purpose, but it is a more dangerous operation, and should only be performed after the subsidence of the inflammatory symptoms.

In large perforating ulcers of the cornea the principal aim must be to prevent the formation of a staphyloma (Fig. xvi.) This can be accomplished by the use of a solution of eserine two grains to one ounce, and a firm pressure bandage. The eserine should be used three or four times a day; the eye being thoroughly washed and cleaned with warm water every time before the application is made. More effectual than this is an iridectomy, but this cannot be performed until the acute inflammatory symptoms have subsided and the other plan can be resorted to immediately after the perforation has taken place. The patients ought to be kept quietly in bed, nor must they be allowed to press the lids forcibly together.

Opacities remaining after ulcerations are often permanent, but superficial maculæ will clear up in the course of time, especially if Bowman's membrane is not implicated. In younger persons, especially children, great changes in the opacity will take place in the course of time, and surgical relief, such as an iridectomy, should not be resorted to too early. As long, as there are blood-vessels to be seen in the opacity, the process of repair is still going on. If the clearing up of the opacities is, however, too slow, it may be hastened by stimulating remedies. Of these the use calomel and Pagenstecher's ointment have been spoken of already. In larger opacities the use of atropia is to be combined with a stimulating remedy. ℞. Atropiæ sulph. gr. ss; zinci sulph. gri. aquæ, ℥ ij. S.—One drop to be put into the eye morning and evening. This has to be continued for weeks or even months. The tincture of opium with saffron (tinct. opii crocata), ten drops to one drachm of water, used one drop mornings and evenings, or a similar application of a mixture of equal parts of ol. terebinth. and glycerine have been recommended. Hot-water fomentations, or an aromatic vapor bath, prepared by pouring boiling water over some German chamomile flowers, and covering the head of the patient and the basin containing the hot infusion with a blanket and allowing the vapors to get into the eyes, by opening and closing them often, is of service, but only in opacities of recent origin. The scraping off of opacities of the cornea should only be resorted to if they are dense and superficial, or if their surface is irregular, or if they are caused by deposits of lime or lead. If the maculæ are central, interfering with the sight of the patient, a new pupil should be made under a clear portion of the cornea. The most favorable position for the new pupil is inwards and upwards; it will be in the line of vision, and its peripheral portion will be covered by the upper lid, which prevents the dazzling effect caused by the entrance of too much light into the eye. Large white corneal opacities are a great deformity, and if there is no probability that they will clear up, *tatooing of the opacity* may be performed. This is done by means of a bunch of fine needles or by a hard, pointed goose quill and india ink. After pricking the cornea, the ink has to be rubbed into it. The effect will not last more than a couple of years, and the operation may have to be resorted to several times. Care should be taken not to perforate the cornea during the operation.

A beginning staphyloma (Fig. xvi.) should be treated as mentioned above; a larger old staphyloma may require an iridectomy to prevent further enlargement. A very large staphyloma will protrude between the eyelids; the cornea thus exposed will soon become dry, and calcareous deposits may be formed on it. Not only on account of the cosmetic effect, but in order to prevent more serious complications of the other eye, an operation should be resorted to under these circumstances. A small staphyloma may be removed by abcision, by means of a cataract knife; the edges of the wound must be brought together by very fine silver or silk sutures. The wound may also be closed by drawing the conjunctiva over it and stitching this together, or in small wounds the use of a pressure bandage alone may be sufficient. The wound has to heal in these cases by granulations. In a large staphyloma, where the wound or the sutures would implicate the ciliary body, it may be more advisable to enucleate the eye, because there is great danger of sympathetic inflammation of the other eye after these operations.

Prolapse of the iris or anterior synechiæ of the iris do not only interfere with the vision of the patient, but they may give rise to dangerous inflammations of the eye. If they cannot be prevented by the use of atropine or eserine, as the case may call for, they should be treated by making an iridectomy, including if possible the adherent portion of the iris.

Destruction of a large portion of the cornea by direct injuries or by ulceration, will, if no staphyloma is formed, result in cicatrization; the cornea becomes flat and much smaller, but it may remain more or less transparent. This is called *phthisis of the cornea, or atrophy of the cornea.* Such an eye will never regain useful sight: even if enough clear corneal tissue remained to tempt us to make an iridectomy, it will not be successful on account of the flat and atrophic condition of the cornea. Phthisis of the cornea is generally associated with an atrophic condition of *the whole* eyeball.

Changes in the transparency of the cornea.—Opacities of the cornea may be congenital, but more frequently they are the result of inflammatory changes; these are maculæ corneæ and leucomæ, see page 118, but there are other opacities that are not the result of inflammation of the cornea. These are lead opacities, the arcus senilis, the ribbon-shaped opacity, and the punctate appearance of the cornea.

Lead opacities are caused by the use of eye lotions containing sugar of lead or the solution of subacetate of lead, applied in inflammatory conditions of the eyes that are accompanied by superficial ulceration of the cornea. In many of these cases the lead forms with the albuminoid matter of the secretion and with the salt contained in tear fluid insoluble precipitates, which will be washed out of the eye by the tears, but if it becomes imbedded in superficial ulcerations, it will form a dense white opacity that can only be removed by operative measures.

Any doubts in regard to the nature of the opacity can be removed by scraping off a small portion of it and placing it under the microscope. Epithelial cells, fibres and numerous granules are now seen; the latter will dissolve at once if a drop of diluted nitric or acetic acid is allowed to get in between the glasses. Other opacities are fibrous and contain few granules; these are not affected by acids. The dense lead opacity differs by its peculiar white color from the bluish semi-transparent opacities of the cornea, the result of inflammatory actions; it is not only a deformity, but it will greatly interfere with the patients vision, if it is near the centre of the cornea. The removal of these opacities is easily accomplished by means of a cataract needle; the patient must be etherized if necessary. The opaque spot remaining after the operation will gradually clear up.

The *arcus senilis* is, as the name indicates, a change of the cornea due to old age: it may form much earlier, however, in certain individuals. The change is due to a fatty degeneration of the corneal cells and a fatty infiltration of the cementing substance. The opacity begins at the upper border first, later on the lower border; these two will later coalesce, forming an ovoid ring around the cornea. This ring will not extend to the limbus, there will remain a clear ring around the opacity, nor will it ever invade the central portion of the cornea, it never gives rise therefore to disturbance of vision. From opacities due to marginal ulcerations it differs on account of the clear ring remaining between it and the very periphery of the cornea. No remedies for it are known, nor are they needed, as the affection is not important.

The ribbon-shaped opacity is a transverse calcareous film beneath the epithelium, corresponding to the palpebral fissure, but not extending to the margin. It is a smooth, faint, hazy opacity, which, stretching across the pupil, interferes considerably with the patients vision. It is very slow in its development and is seen especially on eyes that are otherwise seriously diseased, through irido-choroiditis, glaucoma, or complicated cataract. It affects old or debilitated persons. No remedies have ever done much good towards clearing this opacity, and its appearance is generally a sign of decay of the sight of the affected eye. It is probably due to an excess of lime salts in the blood. Another similar appearance is seen at times in eyes that have been blind for some time; the opacity is, however, quite rough, shows no deposits of lime, but more that of degeneration of the epithelium.

Keratitis punctata.—In the course of a form of iritis, a number of epithelial cells and exudation material become attached to the posterior surface of the membrane of Descemet. The delicate epithelium of this membrane becomes also diseased, and the result is a staining of the posterior surface of the cornea. These point-like opacities are arranged in the shape of a pyramid, whose apex corresponds to the centre of the pupil and the base to the lower segment of the cornea; but at times the dots are quite irregular. Most of the opacities are very fine, like the point of a needle; some are, however, considerably larger. On account of a slight haziness of the aqueous, existing at the same time in some of these cases, it requires the aid of a magnifying glass or the bright, condensed light of a lens to see the dots distinctly. As the main trouble in keratitis punctata lies in the iris, the disease will be described under the head of Iritis serosa.

Changes in the curvature of the cornea are the result of disease, such as staphyloma or flattening of the cornea. These conditions are generally accompanied by a more or less opaque condition of the cornea. But at times spontaneous bulging of a perfectly transparent cornea will take place. It is especially the centre of the cornea, which becomes thinner, then yields, and the result of it is a transparent cone of the clear cornea.

Keratoconus or conical cornea.—The degree of convexity of the cornea varies; it may hardly be noticeable, or the cornea may protrude between the lids. The apex of the cone in these cases becomes hazy, but it is not apt to rupture spontaneously. It occurs chiefly in young people of fifteen to twenty-five years, whose health is delicate and appears to be due to a faulty nutrition of the centre of the cornea, which is farthest from the ciliary vessels; both eyes are apt to be attacked.

The sight of such patients is greatly affected on account of abnormal curvature. They are often moderately benefited by concave cylindrical glasses or by stenopaeic glasses. It has been proposed to cut off the point of the cone and to apply nitrate of silver to the wound every other day. Atropine and a pressure bandage is to be used in the meantime.

Globular cornea, or *keratoglobus*, is a congenital deformity of the cornea. It is perfectly clear, and all its diameters are greatly enlarged; the sclera and anterior chamber are likewise enlarged; the vision is, however, poor and not to be improved by glasses. The difference between cornea and eyeball is the more striking, because the ball is usually smaller than normal. Operative interference is of no avail; an iridectomy may prevent further development, if tried very early in life.

Microcornea is an unusually small cornea; it is generally congenital and associated with other signs of arrest of development. It may, however, be caused also by injuries; in such a case the sight is or will be lost entirely.

Tumors of the cornea are generally dermoid and are located near the edge of the cornea; they have to be dissected off the cornea by means of a knife. Cancerous growths are very rarely seen; they occupy mostly the peripheral portion, and, if seen early, may be removed with ease. Epithelial growths affect the cornea very seldom.

CHAPTER VII.

THE SCLERA.

THE sclera is composed of dense white fibrous tissue; it serves to maintain the globular shape of the eyeball; it is therefore hard, but not very elastic. This explains the intense pain felt in some cases of intraocular diseases, accompanied with increased tension. Its external surface is smooth, its inner surface is grooved by the ciliary nerves. The sclera looks white, and is covered on its anterior half with the transparent conjunctiva; the inner side of the sclera is stained brown and lies in contact with a fine cellular structure, the lamina fusca.

Its anterior margin connects it with the cornea, and its posterior pole is perforated for the passage of the optic nerve fibres (lamina cribrosa), by the ciliary nerves and blood-vessels. It is also perforated in a very oblique manner by the venæ vorticosæ at the equator of the eye and about four mm. from the corneal junction by the anterior ciliary arteries and veins. In the anterior half of the sclera, about 6–9 mm. from the sclero-corneal junction, we find the insertion of the four recti muscles, and in the outer portion of the posterior half, that of the two oblique muscles. The sclera is thicker behind than in front; it is also thicker in the adult. It appears, therefore, perfectly white; in children it is thinner and looks bluish white. Portions of it, thinned by disease, appear likewise blue. A certain and early sign of death, if the eye has not been closed, is a livid discoloration of the sclera corresponding to the shape of the palpebral fissure.

The tissue of the sclera is composed of fibres arranged into fasciculi, intersecting each other, intermixed with elastic fibres. These fibres are like those of the cornea, but they are not so transparent and not so regularly arranged. The fasciculi are arranged in laminæ, and the different layers are held together by a cementing substance like that of the cornea. The nerve and blood supply of the sclera is not abundant. The lymphatics are like those of the cornea, composed of canals and lacunæ. Some of the cells of the sclera contain pigment, especially in the eyes of negroes. The sclera is in intimate relation to the conjunctiva by means of the subconjunctival tissue; the layer nearest to the sclera has been called episcleral tissue. On the inner side the sclera is connected firmly with the choroid near the entrance of the optic nerve, and near the sclero-corneal junction, with the ciliary body.

Posteriorly the fibres of the optic nerve pass through it, but the sheath of the nerve becomes blended with the sclera. Anterior the corneal tissue is continuous with that of the sclera. Here lies a venus plexus and the canal of Schlemm, which communicates with the anterior chamber and the ciliary veins.

Inflammation of the sclera is like that of the cornea, characterized by infiltration of cells, which may result in thickening of the sclera, infiltration scleritis, or in the destruction of the tissues, purulent scleritis.

Idiopathic scleritis is not known. The process begins in the neighboring tissues, the cornea, iris, ciliary body and choroid, or is found to accompany new growths of the eyeball. It may also be the result of an injury. The principal symptoms are hyperæmia and formation of new vessels, which will extend also to the episcleral tissue. The infiltration is seldom so extensive at one given point, that it will lead to the destruction of the sclera, but after the original disease disappears the portion of diseased sclera will become thin; after the absorption of the infiltrated cells, it becomes bluish in color, and is in this condition apt to yield to the intraocular tension, especially if this is increased, and this leads to the formation of a staphyloma. The infiltration of the sclera is apt to occur especially at the places where it is perforated by blood-vessels; this is in the region near the corneal junction or at the equator where the vorticose veins perforate the sclera. We have, therefore, these two regions as the principal seat of staphylomatous formations of the sclera.

Scleritis is a very slow disease, lasting often many months, according to the nature of the primary disease. The treatment must be directed to the main trouble.

Purulent scleritis is likewise no idiopathic disease, but originates from purulent affections of the uveal tract; it is always found in panophthalmitis (Fig xxiv.), or it may be caused by foreign bodies. The principal feature is the infiltration of round cells, which accumulate at certain points to such an extent, that it results in the breaking down of the sclera. This affection is found especially around the parts pierced by blood-vessels, and the sclera is apt to break down at these points, especially at the part where the vorticose veins pierce the sclera, at the equator. This may take place very rapidly, in a few days, but it takes generally many weeks or several months before this occurs. Through this opening the pus that had accumulated in the interior of the eye is apt to discharge. The wound will include the deeper tissues and, may likewise lead to the formation of a staphyloma.

The result of inflammation of the sclera is, as we have seen, apt to be a staphyloma. According to the extent of these bulgings of the sclera, they are called either total or partial staphylomata.

In total staphyloma we have not only the sclera but also the cornea and the rest of the anterior portion of the eye implicated ; it may be congenital, hydrophthalmus or the result of corneal trouble (see cornea), but it is also found to be due to intraocular tumors of the ciliary body, retina or choroid. This bulging is partial in the beginning and is more or less irregular. The diagnosis is, however, not difficult, unless occlusion of the pupil should be present, when the interior of the eye cannot be examined. A staphyloma may be due to a disease of the ciliary body or the choroid, beginning as partial staphyloma and becoming later total.

A partial staphyloma is called, according to its location, either anterior or intercallar staphyloma, ciliary, equatorial, or, lastly, posterior staphyloma of the sclera. The intercallar staphyloma lies in the beginning at the sclero-corneal junction, and is caused by iritis or by irido-cyclitis ; the ciliary staphyloma lies farther back in the ciliary region, and is due to a chronic cyclitis extending to the sclera. It is intimately connected with the underlying tissues, and is, therefore, an elevation of a dirty-bluish color, which is either due to the iris, ciliary body, or choroid. The equatorial staphyloma is in or a little behind the region of the equator of the eye ; it is due to choroiditis, and it is connected intimately with the underlying choroid, but it does not differ materially from any other staphyloma. A staphyloma, it not attended to, may become stationary ; it is, however, apt to develop to such a degree, that it becomes very prominent, but it will rarely rupture spontaneously. A staphyloma is apt to lead to glaucomatous degeneration of the eye, or even to sympathetic disease in the sound fellow eye. A posterior staphyloma begins on the temporal side of the optic nerve, but it has no choroid attached to it, and if looked at with the ophthalmoscope will appear as a perfectly white spot surrounding the optic nerve, from which the choroid has retracted. In the beginning this retraction is in the shape of a crescent or cone, but later, when it becomes more developed, it is quite irregular and may surround the whole disc. It is due to myopia of high degree, associated with chronic sclero-choroiditis, but it is also found in other eyes, if the forehead is very broad. It is not benefited by treatment.

Episcleritis (Fig. xiii.) is an inflammation affecting a localized portion of the deeper layers of the episcleral tissue, and later the sclera itself. It affects generally only one portion, but the plaques may be more numerous. It is characterized by an infiltration of the affected parts, which results in the formation of a slight elevation of a bluish or rosy color, and is covered with conjunctiva, which is also more or less congested. The tumor is generally located on a portion of the sclera near the insertion of one of the recti muscles, especially that of the external rectus, but it may be found in any portion of the sclera, also near to the cornea or nearer to the inner canthus. A distinction should, however, be made, according to the location of this disease, whether the process is near the cornea or not. If a peripheral portion of the sclera is affected, the disease offers a much more favorable prognosis; it will not interfere with the vision of the patient, and although painful, will hardly leave any traces if cured.

It is altogether different if the process is near the sclero-corneal junction; the cornea is surrounded by a hard wall of exudation, which will interfere with the ciliary circulation, and as a result of this, infiltration of the cornea, and later, affections of the iris and sometimes of the ciliary body will follow. Dense opacities of the cornea, sclerosis of the cornea, and broad firm posterior synechiæ of the iris will be the result, and the sight of the patient may be permanently destroyed.

The infiltration of the tissue results in the formation of a roundish elevation. As there is always more or less circumscribed conjunctival irritation present, the true nature of the tumor is only seen by the bluish color — after the superficial conjunctival vessels have been emptied by gentle pressure; the tumor may be very abrupt, resembling a gummy tumor, or it may be less defined and appear only as a slight elevation. These spots are very painful to the touch. It is an affection of middle life and is seldom that it affects young children; it is in most cases due to a gouty condition of the patient, and is sometimes seen in gonorrhœal rheumatism, when the iris is apt to suffer at the same time, and it is one of the secondary manifestations of syphilis. If it is due to a rheumatic condition of the patient, it is apt to be peripheral and very red in color, and a large portion of the conjunctiva participates in the process; it is a very painful disease, but the pain is not so intense as if it were due to syphilis. Here the pain is very severe and especially so at nights; the hyperæmic condition may, however, not be so marked as in the rheumatic kind. The variety located near the cornea is generally found in young strumous persons; it is also very painful. These affections are very tedious, lasting for many weeks or months, the latter variety even for years. It may also be due to exposure, to cold or changes of temperature, and is therefore apt to be met with in spring or winter. The disease might be mistaken for a phlyctenular process of the conjunctiva; but this is most frequently seen in young children; it is not painful to the touch and is more defined in shape. Episcleritis occurs later in life. In phlyctenular troubles we have a depressed ulceration on an elevated basis, and the blood-vessels run towards the fold of transmission; in episcleritis the tumor is rounded, and the injection is more extensive and irregular; its position cannot be changed by moving the conjunctiva, and if pressed upon it reveals the bluish sclera underneath. In cyclitis we have impairment of vision, in episcleritis vision is not disturbed. The treatment must be more constitutional than local. Good hygiene and the use of iodide of potassium, alone or with mercury, in good large doses, seems to be more beneficial than any local remedy. I have given frequently, ℞. Pot. iodidi, ʒvi; hydr. bichlor. gr. i; syr. pruni virgin, tinct. gent. comp. aquæ āā ℥iss. S.—One teaspoonful three times a day. In order to relieve the pain I have used, in cases that could not be treated by hypodermic injections of morphia, a mild astringent lotion with morphia. ℞. Zinci sulph. gr. i; morph. sulph. gr. iv; aquæ ℥i. D. S.—Apply one drop into the eye three times daily, or oftener if necessary. In cases where there is ciliary injection, atropia and warm compresses, or the alternate use of atropia and eserine, have given great relief. Blisters, as counter irritants, have been recommended. The patient should keep in a dry, warm room, and use blue glasses when he has to go out. In rheumatic cases, salicylate of soda, ten to twenty grains three times a day, should be given. Scarification of the episcleral tissue, carefully done, gives great relief in the variety which is near the cornea. An iridectomy, in severe cases with iritic complications, may be made.

Wounds of the Sclera.—They may be caused by sharp cutting instruments or by larger blunt objects. The first produce a wound, which is always of the greatest danger when in the ciliary region, and especially if accompanied by prolapse of the ciliary body or of the vitreous humor, because in such conditions the safety of the other eye is constantly in jeopardy; if the wound is farther back, the choroid is apt to be implicated. Simple uncomplicated wounds, even if large, are apt to heal by first intention, if the edges of the wound are brought carefully together. This can be done in smaller wounds by cleaning the edges of the wound; in larger wounds a small suture of silk, or better of silver wire, may be employed to bring the wound together, which will prevent a collapse of the eyeball, and facilitate a more rapid recovery.

Wounds complicated with prolapse of the deeper parts of the eye require greater care, the prolapsing portion, mostly choroid, if it cannot be replaced by gently rubbing the lid over the wounded region, should be cut off and a pressure bandage should be used afterwards or better, ice-compresses should now be applied to the eye for twenty-four or forty-eight hours; by this time union may have taken place and the sutures can be removed.

If there has been much loss of vitreous accompanying the injury, there is always great danger of phthisis bulbi, and such a wound may lead, even after years, to sympathetic affection of the other eye.

Wounds of the latter class are generally the result of a blow of the hand or of some blunt object. These may simply cause contusion, but if rupture of the sclera does take place, it is generally opposite to the point where the object struck, and lies in the sclera about two or three mm. from the sclera-corneal junction, and is concentric in shape. It does not cause a rupture of the conjunctiva, as a rule, but it may be complicated by a dislocation of the lens or an escape of the lens through the wound under the conjunctiva. It is followed by extensive extravasation of blood under the conjunctiva, œdema of the lids, and extensive hemorrhages into the interior of the eye (*hæmophthalmus*). It will result in great impairment of vision, and is apt to lead to phthisis bulbi or detachment of the retina, or in unfortunate cases even to sympathetic affections of the other eye (see wounds of the ciliary body.)

The treatment should consist of complete rest of both eyes; the patient should be kept in bed in a dark room and ice compresses should be applied every few minutes, for forty-eight hours. A weak solution of atropine, one grain to the ounce, should be used, one drop every two hours. Later a mild stimulating lotion of arnica and sugar of lead may be of service. ℞. tinct. arnicæ, ℥ss; liq. plumbi subac. ʒj; aquæ, ℥vj. S.—Applied to lids three or four times a day. Blue glasses must be used for a long time after all local inflammatory symptoms have disappeared, to prevent all irritation of bright light. Shortly after the injury mild saline cathartics may be useful. If the lens is dislocated at the same time, it may be removed by an incision of the conjunctiva after the healing of the scleral wound, because its pressure in the region of the wound might do harm.

CHAPTER VIII.

THE IRIS.

THE iris is a membranous curtain, perforated in the centre and suspended in the anterior chamber in front of the lens. It divides the aqueous chamber of the eye into two sections; one, larger and in front, is called the anterior chamber, and a smaller one behind the iris, the posterior chamber; as the iris rests only lightly on the lens, the exchange of the fluid contents of the two chambers is free.

The function of the iris is to shut off the rays of light going through the periphery of the lens and also to regulate the amount of light that enters the eye during the act of vision. The central opening of it, called the pupil, must therefore dilate when there is little light to see by, and contract when there is much light. This action is, however, not only regulated by the amount of light, but also by the sensitiveness of the retina; it is therefore less marked in atrophy of the optic nerve and retina, or in cataract, which prevents the light from reaching the retina. Immobility of the pupil to approaching light is said to be a sure sign of death. Should there be any obstacle, preventing the free action of the iris, vision must necessarily be impaired. This important action of the iris is greatly facilitated by its mode of attachment. It is entirely free, except at the periphery; here it is attached firmly to a prolongation of strong fibres from the posterior surface of the cornea, but not to the cornea itself. These prolongations run backward like a network; they are called the ligamentum pectinatum, or Dollinger's band. It is covered by a layer of epithelial cells, filling up the spaces between the prolongations. These spaces are called Fontana's spaces, and are regular canals in some animals, as the ox. They are of great importance in the filtration of fluids of the eye, and if they become impermeable, they lead to an increase of pressure in the eye, which is one cause of a formidable disease called Glaucoma, of which we shall speak later.

More intimately than with the cornea, the iris is connected with the ciliary body, to which its periphery is principally attached by its stroma and its blood-vessels and nerves; in fact it may be looked upon as a continuation of the ciliary body and the choroid, and affections of one portion will extend frequently to the other portions of this tract, which has been called the *uveal tract*, on account of the bluish-black pigment common to these parts, resembling the color of the grape. On account of these relations to the ciliary body, the peripheral border of the iris is called the ciliary border, the free border is the pupillary border. In the fœtal state the pupillary space is covered by a delicate membrane, the pupillary membrane, which in very rare cases remains permanent; but in all other cases obstructions of the pupil are the results of disease. The iris is composed of different layers; the most anterior is a layer of flat epithelial cells, which are continuous with those of the ligamentum pectinatum, and through these with those of the posterior surface of the cornea. Next comes the iris tissue proper, or stroma of the iris, which is made up of a loose network of fibres, most of these are radiating from the pupil to the periphery; many of the fibres are elastic, which enables us to pull the iris out of the anterior chamber during operations. This network of fibres contains cells, many of which contain pigment. This gives the iris its peculiar color, which is generally in harmony with the hair. If these cells contain a good deal of pigment, the iris is black or brown; if only some of them contain pigment, or if there is no pigment at all in them, the iris appears blue or hazel, which is due to the black background, the posterior pigmentary layer of the iris.

The stroma of the iris contains a number of muscular fibres which are of the involuntary, smooth, non-striped variety, namely the fibres of the sphincter and those of the dilator of the pupil. The fibres of the sphincter are arranged near the pupillary border, concentrically, and by their contraction the pupillary space becomes smaller (*myosis* contracted pupil.) This is principally produced by the irritation of light, but also by other processes which we shall consider later. This muscle is supplied by a small branch of the third or motor-oculi nerve. The other fibres are those of the antagonist, the dilator of the pupil; these fibres are arranged in delicate fasciculi, running in a radiating direction and are found especially near the ciliary border, but extend almost to the pupil. By the action of this muscle, which is controlled by the sympathetic branch of the ciliary ganglion, the iris dilates (*mydriasis*, wide pupil). Next to the stroma we find a very delicate structureless tissue, the elastic lamina of the iris, and posterior to this the pigmentary layer. This is composed of a large number of irregular cells, filled completely with dark pigmentary molecules. When the pupil contracts, portions of this layer project often into the pupillary space, giving the pupillary border a serrated appearance. The function of this layer is to absorb the light penetrating the iris, which would otherwise disturb vision. In the albino this pigment is absent.

The blood-vessels of the iris are very numerous; they are derived from the internal carotid. The long ciliary arteries perforate the posterior portion of the sclera, near the entrance of the optic nerve and pass forwards in the lamina fusca, in the region of the internal and external rectus, up to the origin of the iris; here they divide into two branches, which unite with those of the opposite side and thus form the large arterial circle of the iris. This circle also receives blood from the anterior ciliary arteries; these are small vessels which arise from branches of the muscular arteries. These branches, after leaving the insertion of the recti muscles, pass forwards near the sclera up to the sclero-corneal junction and divide into two branches, one superficial, going to the periphery of the cornea, and one deeper and larger branch, which joins the larger arterial circle of the iris. The large circle sends off many branches, some of these, passing backwards, establish an anastomosis with the branches of the short posterior ciliary arteries of the choroid and the ciliary body, but those passing forwards, after freely anastomosing with each other, meet at the pupillary margin of the iris and form here the smaller arterial circle of the iris.

The veins of the iris run backwards to the ciliary body and choroid and empty into the venæ vorticosæ or leave the eyeball near the sclero-corneal junction and empty into the deeper conjunctival veins. These branches are especially engorged in inflammatory processes of the iris, cornea, or ciliary body, and together with the engorged arteries form that peculiar bluish-red injection near the sclero-corneal junction, known as the ciliary injection. Of the nerves going to the iris we have partly spoken already; they are the fibres of the third, which goes to the sphincter, and a branch of sympathetic origin, which goes to the dilator of the iris. The sensitive nerves are derived from the first division of the fifth. These nerves come from the ciliary ganglion and are called ciliary nerves. The sensitive fibres are especially abundant in the iris, and operations or injuries of the iris are therefore very painful. Besides these sensitive fibres coming from the ganglion, several small branches, two or three in number, are derived directly from the nasal branch of the fifth nerve; these are called the long ciliary nerves and pierce the eyeball also near the entrance of the other ciliary nerves.

The iris, as we have seen, differs in color according to the quantity of pigment of its stroma; sometimes the pigment accumulates in spots and gives the iris a dotted appearance, which might be taken for foreign bodies or for products of disease, but the absence of irritation will make this part of our diagnosis easy. Sometimes the amount of pigment differs in the two eyes, or it may be entirely absent, as for instance in albinos. When the iris is contracted, it presents an uneven surface, as if it had been folded; these undulations are called cryptæ; they disappear when the iris becomes inflamed and begins to swell. The pupil likewise differs; it is generally not directly in the centre, but a little more to the inner side, and is of different size in different individuals. As a rule it is small in early infancy and small again in old age; it is large in near sighted people, small in hypermetropia. In some people it is oval or pear shaped; but as a rule, if not congenital, a change in the shape of the pupil, and especially a difference in the size of the two pupils, ought to be looked upon as a sign of a morbid process. We must not forget that we see the iris slightly magnified by the cornea and the aqueous humor.

Anomalies.—Total absence of the iris is *iridcremia.* It may be the result of an extensive injury, and is then only seen in one eye, but generally it is congenital. Such patients do not see well, because too much light enters the eye; they prefer to live in the dark. On ophthalmoscopic examination the whole fundus appears like a large red disc, and the outlines of the lens can be distinctly seen. *Treatment:* dark blue or smoke colored, but especially stenopæic glasses will not only give relief from the great amount of light getting into the eyes, but will also improve the vision.

Coloboma of the iris is the absence of a portion of the iris. It is sometimes congenital and may be relieved by dark glasses, but generally it is the result of an operation (artificial pupil after iridectomy). Tremulous iris (*iridodonesis*) is seen in patients who have either lost the lens entirely, or in cases where the lens has been dislocated and is pressing against a portion of the iris, or it is due to a very fluid consistency of the vitreous body; it is seen best if the patient shakes his head, or if he looks up or down suddenly, when the wavy or trembling appearance of the iris becomes very manifest.

Iridodialysis is that condition in which the iris has been partly torn loose from its ciliary attachment. It is generally the result of an injury, and may also happen during an operation, when too much traction on the iris has been made. Total iridodialysis results in irideremia, and the torn off iris is either found at the bottom of the anterior chamber or in the wound, or it has escaped out of the eye.

Changes in the mobility of the iris. All the muscles of the iris may be paralyzed (*iridoplegia*); this may be the result of some serious lesion of the eye, when from continued pressure of the iris this becomes paralyzed. If this is accompanied by a change of the color of the iris, it is usually the result of an old irido-choroiditis. Immobility of the iris occurs when the pupillary margin of the iris becomes firmly attached to the lens, in occlusion or exclusion of the pupil. If these conditions exist for any length of time, they will be followed by great atrophy of the stroma of the iris.

Paralysis of one of the muscles of the iris will result in either a contracted pupil, if the dilator is affected, or in a large pupil, if there is a paralysis of the motor oculi nerve. This latter condition causes only a moderate dilatation of the pupil, of five to six mm.; it is generally associated with paralysis of other muscles of the eye supplied by the same nerve, but it may also appear as the only sign of an affection of the nerve. Mydriasis paralytica is generally due to some central lesion, and is a very valuable diagnostic sign if accompanying central troubles, but it may also be caused by pressure on the nerve on its passage through the sphenoid fissure, and in rare cases it is merely a peripheral trouble of the nerve itself. It may be traumatic, caused by blows, and is sometimes due to exposure, but more frequently it is due to specific troubles. Paralytic mydriasis is generally associated with paralysis of the accommodation, and the vision of the patient is disturbed, for near objects especially, because he is not able to accommodate, nor does he see well in the distance, because too much light enters the eye, but he is able to see well in the distance through a small hole in a card, since this shuts out the superabundant light. If the vision is not improved by this plan, the probability of a diseased condition of the optic nerve or retina calls for a careful examination of these parts.

Treatment.—If the paralysis is due to central causes, these ought to be treated: if syphilitic, the proper specific remedies should be ordered, especially large doses of iodide of potassium, say forty to sixty grains a day, are required; if due to peripheral causes, such as rheumatism, the use of iodide of potassium, or salicylate of soda is called for, but in all these cases the use of the faradic current must not be neglected. The second variety of mydriasis, without paralysis of other muscles, is very tedious, and may last for such a length of time that complete atrophy of the sphincter will follow. In order to avoid this, and to enable our patient to use his eye during the day, and also for cosmetic effects, the use of one drop of a solution of sulphate of eserine (two grains to one ounce of water) in the morning will be called for. Eserine may be continued for a long time without the slightest irritation of the eye, and may facilitate the cure by the mechanical exercise of the muscle. The use of strychnia, hypodermically, is also of great service, one twenty-fourth of a grain should be given. Mydriasis paralytica generally affects only one eye, and gives the patient a very peculiar appearance; if both eyes are affected the mydriasis is generally due to other causes, such as atropia, but on the other hand, mydriasis of moderate amount of both eyes accompanies often brain lesions of various kinds, and an atrophy of the optic nerve with wide pupils is usually due to brain troubles. Mydriasis is also found after irritation of the sympathetic (intestinal worms), but in such cases it is not of long duration. It is also found in complete prostration of the nervous system, typhoid conditions and profuse narcosis of chloroform. Myopic eyes also have a large pupil. Relaxation of the accommodation is likewise accompanied by dilation of the pupil.

Mydriasis is also the result of the action of certain remedies called *mydriatics*, which are principally derived from the family of solanaceæ. They are:

Belladonna, and its principal ingredient, Atropine.
Stramonium " " " " Daturine.
Hyoscyamus " " " " Hyoscyamine.
Duboisia myoparoides " " Duboisine.

Belladonna is seldom used, generally in the form of the aqueous extract, ten or twenty grains to one ounce of water; it has to be filtered. Atropine may be used in solutions of one to two or four grains to an ounce of water. For children it is not safe to use a stronger solution than one grain to one ounce, nor is it safe to give a patient a stronger preparation than a two grain solution for his own use; a four-grain solution ought to be used only by an expert. Always use the sulphate of atropia; never add any sulphuric or other acid to keep it in solution, and have it frequently renewed. In using it, direct the patient to look upwards, pull down the lower lid and let the solution fall into the eye, so that it can reach the cornea. Let the patient hold his head to one side, so that the surplus of the atropine runs out of the outer canthus and keep the lower lid pulled down for some time. Using this precaution the poisonous action of the drug is seldom felt. If the atropine runs through the nasal duct into the throat, it produces great dryness, bitter taste, great thirst, and the secretion of a viscid, thick mucus. This will be followed by slight febrile symptoms, which may become very marked in children, and may be accompanied by an erythema of the face, and sometimes of the whole body, resembling scarlatina; palpitation of the heart and frequent micturition, with great irritability of the patient may follow, and the pupil of the fellow eye will also dilate. The effect, however, will pass off soon, and the use of antidotes, of which the common paregoric is one of the best, is hardly ever necessary. Stramonium and daturine are not so powerful and may be used in those cases where atropine produces great irritation of the eye, which it will do in some persons, see conjunctivitis page 106. Use a five-grain solution of daturine in these cases. Hyoscyamus and hyoscyamine are very little used.

Duboisine is perhaps the best substitute for atropine; it is more energetic and prompt in its action; dilatation of the pupil will be accomplished in ten to fifteen minutes by it and the effect is not so lasting; but it is even a more powerful poison than atropine and ought to be used very carefully. Use two or four grains of duboisia to one ounce of water.

Homatropine has been used with great success, where a long continued dilatation of the pupil had to be avoided, (two grains to one ounce of water); its effect will last only about twelve hours. The duration of the effect of these drugs is different, but the pupil will generally remain dilated for five or six days, and the effects of atropia are sometimes felt for more than a week after the use of this remedy. The dilatation of the pupil is not only produced by the local applications of these drugs, it is also seen after the internal administration as soon as the constitutional effect of the drug begins to show itself.

Myosis means a contracted pupil; it may be the result of paralysis of the dilator; this is very rare; or it may accompany spinal troubles, and in these cases the pupil may become very narrow (pinhole pupil). It is also the result of reflex irritation from the fifth nerve, caused by foreign bodies in the eye, or by bright lights. Efforts of accommodation and convergence produce a narrow pupil and in sleep the pupil is likewise contracted. Myosis may be the result of the action of drugs, the remedies producing this effect are called myotics; they are:

Calabar bean, and its principal ingredient, Eserine.
Opium " " " Morphine.
Jaborandi " " " Pilocarpine,

and also lactuca virosa, aconite and digitalis. Of these the Calabar bean and eserine and also the pilocarpine are used to produce contraction of the pupil. Eserine is to be used in a solution of two or four grains to one ounce of water, Calabar bean extract is generally used in small gelatine discs, or in bits of paper saturated with the extract. Pilocarpine may be used in solution or by the hypodermic syringe.

The effect of the other remedies, opium, lactuca, aconite and digitalis is only seen when taken internally. In cases of opium poisoning the narrow pupil is a valuable diagnostic sign.

Tumors of the iris are rare, they are mostly gummata and accompany specific iritis, or they are cancers, which are generally extending from other tissues to the iris.

Cysts of the iris are generally serous, varying from the size of the head of a pin to a small marble; they are bluish, semi-transparent or dark in color and project into the anterior chamber. For their removal a surgical operation is necessary.

Iritis (Figs. xvii. xviii. xix.)—An inflammation of the iris is often met with. On account of the great vascularity and great number of nerves in the iris, it is a very painful disease, accompanied by marked inflammatory symptoms. According to the nature of the product of the inflammatory action, we have a serous, a plastic or a purulent iritis. However in a case of serous iritis we shall always find more or less plastic material thrown out; in a purulent iritis, and in a plastic iritis, we must likewise expect to find some effusion of serum.

There are certain features which are common to all these varieties of iritis; let us consider them first. Preceding the inflammatory action, we have great hyperæmia of the iris; the numerous vessels of this structure become engorged and increase its volume; its tissues look swollen and spongy; the ciliary vessels become very prominent and the ciliary injection (Fig. xvii.) of the eyeball becomes very marked, see page 156; the pressure of the engorged vessels on the nerves produces great pain from the very beginning, which is increased whenever the muscular tissue of the iris is called upon to act; there is also great sensitiveness to light.

As soon as the inflammation is established, these symptoms are greatly increased and others become manifest. As the inflammatory products in the iris tissue increase, the color becomes changed; it becomes swollen and naturally crowds into the pupillary space; the pupil becomes quite narrow, and the muscles which before, during the congestive stage, acted only under strong stimulations, refuse to act now; the iris is immovable. The exudation forces its way through the external epithelial layers, loosens the epithelial cells and these become mixed with the aqueous humor; the aqueous humor becomes cloudy and opaque on account of the presence of the epithelial cells and of the inflammatory products; this must not be mistaken for an infiltration of the cornea to which it has a strong resemblance; there is also some exudation into the vitreous, which may be sufficient in some cases to cause an increase in the tension of the eyeball and impairment of vision. This is principally due to the cloudiness of the aqueous humor, but also to that of the anterior portion of the vitreous, which becomes slightly hazy on account of the infiltration. Pain is always one of the principal features of the disease, except in chronic forms; it is not so much the pain in the eye that the patient complains about, it is the so-called ciliary neuralgia, the pain along the branches of the supraorbital nerve; but frequently the whole side of the face is painful, and I have seen many cases, that had been looked upon as cases of brain fever, which were simple cases of iritis. In all varieties of iritis the pain seems to be very severe about two to four o'clock in the morning; this is especially true in cases which are due to syphilitic troubles. In acute cases of iritis, we have often a high febrile condition and this is more apt to mislead the patient and cause him to imagine that he is suffering from some constitutional disease. The fever lasts generally only during the first few days and yields readily to antiphlogistic remedies. Together with other products of the inflammation, we shall find plastic material, which is not only mixed with the aqueous humor in the anterior chamber, but is found especially between the iris and lens. The result of this is a gluing together of the iris and lens. This may be very extensive or affect only a few places. A few drops of atropine, put into the eye, will tell us how extensive this adhesion is; the part loosely, or not at all adherent to the lens, will yield readily to the action of the atropine and dilate, whereas the adherent portion cannot do so. The result of it will be an irregular contour of the pupil, which may be drawn altogether out of shape or may be drawn only to one side. (Fig. xviii.) These adhesions are called posterior synechiæ, because the iris is adherent to something on a plane posterior to it and differs from anterior synechiæ because in these the iris is adherent to something in front of it, the cornea. (page 118).

If the free edge of the iris is entirely adherent and does not yield to the action of atropia, the pupil remaining narrow, we call it exclusion of the pupil, and if the plastic material fills the entire pupillary space, we have an occlusion of the pupil. This results of course in entire loss of vision, which lasts as long as the exudation remains in the pupillary space; the patient will only be able to distinguish between light and darkness, as some light will penetrate through the iris tissue. Another prominent feature is the injection of the blood vessels; the ciliary vessels are the ones principally affected. A well marked rosy zone of injected ciliary vessels will be seen radiating from the corneal margin (Fig. xvii); but soon the conjunctival vessels, which freely anastomose with the ciliary vessels, will also become congested and frequently to such a degree, that the whole eyeball appears red; but as I pointed out before, the principal redness is to be found around the cornea, and near the fold of transmission, the injection is comparatively slight. We have therefore a number of subjective and objective symptoms of iritis, which, to recapitulate, are as follows, (a) subjective; 1. *pain*, which is very severe especially at night, and may affect the whole side of the head; 2. *impaired vision*. The patient may not have noticed this at all, and only by testing the vision of each eye separately will he become aware of the diminished vision; at other times this may be one of the principal reasons that induces the patient to seek medical advice. 3. *Photophobia*. This differs in the different varieties of iritis, but is generally a prominent symptom. 4. *Lachrymation*. This is a very annoying symptom, due to reflex irritation of the fifth nerve. It is generally relieved by the free use of atropine. 5. *Fever*. This varies considerable in different cases and may be entirely absent in slight attacks. (b) The objective symptoms are in the beginning those of the hyperæmic state only and later those of inflammation. 1. *Ciliary injection* (Fig xvii.); this is the most prominent and is so marked, that an expert may recognize the condition from a distance; it is generally accompanied with more or less general conjunctival injection. 2. *Discoloration of the iris*. This becomes especially manifest by comparing the eye with its healthy fellow eye and is due to the abundance of blood in the engorged vessels of the iris, or to the products of the inflammatory action. The blood vessels of the iris are never visible, except in cases of long continued inflammation, resulting in great changes in the stroma of the iris. 3. *Contracted pupil.* The pupil is not only narrow, but it does not respond to the action of the light, which gives us 4. *an immovable pupil.* If this dilates only partly under the influence of atropine, it will form 5. an *irregular pupil* (Fig xviii). 6. A *spongy swollen* appearance of the iris, due to the engorged vessels and to the presence of inflammatory products. 7. *Cloudiness of the aqueous humor*, this is due to the presence of epithelial cells of the iris and inflammatory products. 8. *Deposits on Descemet's membrane*, which appear punctate; the epithelial cells of the iris become attached to the cornea, especially in iritis serosa. 9. *Condylomata*, when the product of the inflammation is accumulated in deposits varying in size, forming slight elevations on the iris, principally in specific iritis. 10. *Posterior synechiæ.* They may be very small, like the point of a pin, or may form broad bands, uniting firmly iris and lens; they are best seen with the ophthalmoscope or by oblique illumination. 11. *Œdema* of the upper lid frequently accompanies iritis, especially the traumatic variety and is after cataract extractions generally a significant symptom. The most important diagnostic symptoms of iritis are, therefore, (1) pain, (2) impaired vision, (3) photophobia, (4) lachrymation, (5) ciliary injection, (6) discoloration of iris, (7) contracted pupil, (8) immovable pupil, (9) irregular pupil, (10) cloudiness of aqueous humor, (11) posterior synechiæ.

All these symptoms may be very prominent in acute iritis, but we meet sometimes with chronic affections of the iris, in which the first subjective symptom of the patient is impairment of vision, which may or may not have been preceded by slight headaches and where the objective signs of the disease are more or less extensive synechiæ and slight changes in the color of the iris. If in these cases the iris is very much discolored, there is great probability of choroidal complications.

Before speaking of the ethiology and treatment of iritis, let us consider the different varieties. 1. *Iritis serosa.* This form of the disease is always more or less chronic and is apt to lead to serious changes in the eye. As the name implies, the principal product of the disease is serum. We shall have therefore a marked increase of tension of the eye in acute cases, which produces some pain; but the subjective symptoms of pain, photophobia, lachrymation and fever are not very marked. The vision is impaired from the beginning. The quantities of serum passing through the epithelial layer of the iris loosens many of its cells, which are now found floating in the anterior chamber, and prevent acute vision. These flocculi, composed of epithelial cells and some plastic exudation, will eventually become deposited on the membrane of Descemet and will give this part of the cornea a peculiar punctate appearance; it is therefore called:

Descemitis or *Keratitis punctata.*—The adhesion of the flocculi to the membrane of Descemet becomes quite firm, forming little dots. These points are generally arranged like a pyramid, with its apex corresponding to the centre of the pupil and its base to the lower peripheral portion of Descemet's membrane; this arrangement may be caused by the action of the contracting iris on the settling deposits of the aqueous humor. There is always more or less plastic material thrown out between the lens and iris, and very extensive synechiæ may be encountered in the treatment of this affection, but as a rule there is less tendency to the formation of synechiæ in this form of the disease. It is sometimes the beginning of a *sympathetic ophthalmia* and it will also frequently lead to great changes in the ciliary body and choroid and even in the lens and may last for years, in spite of all our efforts. Our prognosis should always be guarded, though in young persons, with good care and rest, it will disappear entirely.

The second variety, *plastic iritis* (Fig. xviii.) is of frequent occurrence; it is as a rule acute and the symptoms of it are so marked, that the patient will soon seek advice. The principal feature of this variety is the large quantity of plastic material thrown out. The pupil will be very narrow and the lens and iris will be firmly glued together. There will be great disturbance of vision, especially if the ciliary body becomes also affected; in this case the eye will become very painful. Seen with the ophthalmoscope, we find that the refractive media are not clear, the aqueous and often the vitreous become so cloudy that little or no reflex of the background of the eye is seen. After the use of atropia the aqueous becomes clear, the pupil will partly dilate and the vitreous opacities will appear like a cloud; the red reflex becomes distinct, but the details of the fundus cannot be seen till the vitreous becomes quite clear. The pupil appears more or less irregular and the synechiæ look like black stitches or small bands, uniting the lens and iris; frequently we find masses of exudation on the capsule of the lens, or after the adhesions have been torn loose, small black spots remain, which are composed of plastic material and pigment of the iris. If abundant, they may interfere with vision; they have been called spurious cataracts, but they may lead to changes in the nutrition of the lens which ultimately may result in true cataract. Together with the synechiæ, we find at times that the tissue of the iris is very much swollen, and spongy, and that atropia has hardly any effect on it; this variety is generally due to syphilis. In another variety the process is accompanied by a number of small elevations on the iris, *condylomata* (Fig. xix.); they are looked upon as gummata and are almost exclusively found in the syphilitic variety and are considered pathognomic of specific iritis, iritis gummosa, see (Fig. xix). In the plastic variety we are apt to find synechiæ that will not yield to treatment and remain after all inflammation has subsided; they are apt to be the source of relapses, but by far the most frequent cause of the relapses is the condition of the system, which produced the first attack and which is generally of a specific or rheumatic nature. We have therefore often both eyes affected with the same trouble, or it is apt to go first to one eye and later to the other.

The third variety is the *purulent iritis;* here the main product of the inflammatory action is a proliferation of cells and the formation of pus. The pus is to be found not only in the iris tissue itself, where it produces marked changes of color, but especially in the anterior chamber, where it forms *hypopion* (Fig. xv). Hypopion is therefore not only due to corneal ulcers but also to iritis. This form of disease is generally the result of an extension of a purulent process from the choroid, as for instance in quently looked upon as a catarrhal conjunctivitis. The treatment of these two affections is however so very different, that a mistake of this kind might cause the loss of sight of the diseased eye. The differential diagnostic signs are as follows:

IRITIS.	CONJUNCTIVITIS.
1. Injection pericorneal, ciliary, deep; vessels small, radiating from the cornea, rosy in color or bluish; conjunctival vessels often very engorged.	1. Injection *especially* near fold of transmission, superficial, with small hemorrhages; vessels large, irregular and bright scarlet.
2. Pupil immovable.	2. Pupil dilates and contracts easily.
3. Vision impaired.	3. Vision not affected.
4. Pain severe, radiating to side of head and brow.	4. No pain, slight sandy sensation in eye.
5. Photophobia.	5. Hardly any photophobia.
6. Lachrymation only.	6. Discharge thick, muco-purulent.

Cyclitis is frequently associated with iritis: in cyclitis the pain is even severer than in iritis; the eyeball is very painful to the touch in certain regions, and the impairment of vision is more pronounced in cyclitis. From neuralgic pains, iritis is easily differentiated by the impaired vision and the inflammatory symptoms.

Ethiology.—We have spoken of some of the causes of iritis already. Perhaps the most frequent of all is injury to the iris, either by a lacerating wound, or by the entrance of a foreign body into the eye. If a foreign body enters the eye, it is more apt to find its way through the cornea, leaving a small macula corneæ at its point of entrance; if it is larger we find frequently prolapse of the iris accompanying the injury. Anterior synechiæ in an eye that has been struck by a foreign body is therefore a pretty sure sign of the presence of a foreign body in the eye. In order to remove this in such a case, it is generally necessary to make an iridectomy at the point where the anterior synechia has formed, in which case the foreign body can often be reached by the forceps or by a magnet; again, a foreign body may rest on the iris or be embedded in its tissue for years without giving the patient any trouble, till exposure to very bright light and great efforts of vision or accommodation will lead to irritation and inflammation. The trauma may however not affect the iris directly; a severe concussion of it may set up an inflammation. Operations on the iris or other parts of the eye may lead likewise to iritis, by either bruising or pulling the iris too violently. The second cause in frequency is syphilis. Iritis is generally one of the later secondary manifestations of

acquired syphilis and may appear months or even several y
after the primary infection; but it may be one of the earl
secondary symptoms and even precede the roseola of the boc
I have seen it as early as three and four weeks after the
pearance of a chancre. It is often accompanied by a papula
syphilitic eruption of the face, the corona veneris. Extensiv
synechia, great tumescence of the iris or condylomata character
ize this trouble. (Fig. xix.) The nocturnal attacks of pain are
especially marked, they are more of a hemicranial character. If
due to congenital syphilis, it is as a rule accompanied by diffuse
keratitis.

Another cause is rheumatism. Iritis may be the forerunner of rheumatic attacks, but it generally follows in their wake, and it is but seldom that it occurs simultaneously with an acute attack of articular rheumatism. This variety is sometimes seen in gonorrhœal rheumatism and is generally accompanied with intense conjunctival complications, slight chemosis and œdema of the lids and great pain, photophobia and lachrymation.

Iritis may also be due to great depression of the system after exposure and severe diseases; it may likewise be the extension of inflammatory conditions of neighboring tissues, for instance of the ciliary body, but especially of the choroid, and of the cornea. Traumatic and diffuse keratitis and ulcers, due to granulated lids, are apt to be accompanied by iritis. Diseased conditions of the fellow eye, especially injuries of the ciliary region, or foreign bodies lodged in the eye, may lead to sympathetic disease, which generally begins as an iritis and soon extends from this to the deeper tissues of the eye. Iritis is generally a disease of advanced age, occurs between twenty and fifty years and is seldom found in children, except as complication of other troubles and affects more frequently men than women, because they are more exposed to the causes leading to it.

Treatment.—The main indication in the treatment of all varieties of iritis must be the prevention of synechiæ and this is best accomplished by the early and vigorous use of atropia. The physician ought to give this his personal attention; he may use a four grain solution of atropia, two drops every five or ten minutes till the pupil is entirely free and fully dilated, or at least almost so. Of course he must observe all the precautions given about the use of atropia, and must discontinue it as soon as the patient complains about dryness of mouth and throat or bitter taste. After full dilatation of the pupil has been accomplished, it is absolutely necessary to maintain it as complete as possible.

The patient may use now a two grain solution every two, three or six hours as the indications may be. If the nocturnal pains set in, it may be used also at nights, before as well as during the attacks. By the contraction of the dilator muscle, the blood-vessels of the iris are depleted, there is less pressure on the nerves and consequently less pain; the effect of the atropia is however an anæsthetic one at the same time. Always let your patient keep his lower lid and the puncta drawn away from the eye and the head inclined towards the outer canthus and the atropia is not so apt to get into the throat and cause symptoms of poisoning. The next indication is to relieve the hyperæmia of the blood-vessels of the iris; antiphlogistic remedies are to be given, such as the sulphate or citrate of magnesia and if the pain is not relieved by atropia and the injection is very marked, two to six leeches are to be applied to the corresponding temple, or after making a very small crucial incision in the temporal region by means of a scalpel or thumb-lancet, draw the blood by means of a soft rubber cup, or the cylinder of a hœurteloup. These latter are easily applied, are not so much objected to by the patients, especially ladies and children as the leeches, and the amount of blood drawn can be regulated more accurately. The loss of blood diminishes the tension of the blood-vessels of the iris and also of the whole anterior portion of the eye, and the atropia is absorbed more readily. This is also accomplished by the application of hot water. Irritation of the eye ought to be avoided as much as possible. Rest of the eye, in fact of both eyes, is absolutely necessary; keep your patient in a dark room, and if possible in bed. Keep the room at an even temperature and avoid draughts as much as possible. On this account the treatment of patients who will, or cannot keep to their beds is much shorter and more successful in summer than in winter, and an attack that will last from six to eight weeks in winter, will possibly last only a couple of weeks if it comes on during the warm summer months. If your patient cannot stay in-doors, order for him very dark blue glasses, which may be changed for lighter ones during the later stages of the disease. They are better than shading one eye alone, because the light entering the fellow eye will simultaneously irritate the diseased eye. On this account reading and writing, in fact all accommodative efforts must be avoided.

Next in order comes the constitutional treatment of the causes of iritis. The chief remedies at our disposal are mercury iodide [illegible]. In specific iritis mercury ought to be used promptly until the constitutional effect of it is produced. It is perfectly wonderful how rapidly at times pain and injection will subside after a few applications of a mercurial preparation. The synechiæ seem to melt away like snow on a warm day, the peculiar syphilitic cachexia disappears and the patient is able to face daylight without trouble. My favorite prescription is: ℞. Ungt. hydrarg. ciner. ℥ss; divide in parts No. vi. One of these packages contains forty grains of the ointment. The salve may be applied to the sole of the foot at nights on going to bed, one day to one foot, the next day to the other; the patient ought to keep on his socks during the night after the application. It may also be rubbed under the arm pit. In females or in young patients or in milder cases of the disease, twenty to thirty grains will be sufficient for one application. Another more elegant but also more expensive preparation is the oleate of mercury, and especially a preparation of the oleate of mercury and morphia (Squibb's.) This may be painted by means of a camels hair pencil to the temple or better behind the ear of the affected side at nights on going to bed; wash off the place the next morning and apply a little cold cream to it. The following prescription will answer for milder and for chronic cases. ℞. Hydr. protoiod. gr. vi; extr. nuc. vomic. gr. iv; ext. aloes aqu. gr. xii; extr. conii gr. x; m. f. pil. No. xxx. S. Take one of the pills three times a day and later twice a day only. In other cases the mixed treatment is borne better. As the Iodide of Potassium is apt to disturb the digestion more or less, I am in the habit of giving it with some bitter tonic, like the compound tincture of Cinchona or Gentian. Another pleasant addition is the fluid extract of senna, which is useful or even needed in most cases. ℞. Bichloride of hydrargyrum gr. i; iodide of potassium ℥ss; fl. extr. of senna ℥i; syr. sarsapar. comp. ℥i; tinct. cinchonæ ℥ij. S. One teaspoonful in water half an hour after meals, three times a day—or the following formula, which is less expensive: ℞. Biniod. of hydrarg. gr.i; iodide of potassium ʒij; tinct. gent. co. ℥iv. This is to be given in the same way as the first preparation.

In rheumatic iritis the salicylate of soda ten to fifteen grains, three times a day; or the iodide of potassium, six to ten grains three times daily, have given great satisfaction. If there is more or less febrile disturbance, quinine in five-grain doses may be given three times a day.

Warm compresses are also very useful; they relieve the congested vessels and the absorption of the atropia is very prompt after its use. They ought to be as warm as the patient can bear them and should be continued for ten or fifteen minutes; one drop of atropia is to be used before and two after bathing. Warm water alone or better a mild infusion of German chamomile flowers or an infusion of poppy heads on account of their anodyne properties, may be used. A vapor bath applied to the eyes only, or a Turkish bath if possible, and in cases of syphilitic iritis a mercurial bath will produce excellent results.

In traumatism of the iris, ice-compresses and atropia ought to be used to prevent an inflammatory attack, but after this has once been established and exudation taken place, warm water and atropia is preferable. Anything that has a tendency to increase the flow of the blood to the head, such as stooping, ought to be avoided, strong coffee and all stimulants must be forbidden. On this account patients sleep better as a rule in a sitting posture than lying down in bed. The moderate use of morphia, especially hypodermically, is indicated in cases of severe nocturnal pains that do not yield to atropia, leeches or warm compresses.

Treatment of the sequelæ of iritis. Posterior synechiæ may not be torn entirely during the treatment of the disease, if they are small, they do not interfere with the act of vision materially; they may become entirely absorbed after the long continued use of iodide of potassium internally and locally into the eye; two to four grains of it to one ounce of water do not irritate the conjunctiva and may be used two drops mornings and evenings, to be dropped into the eye. The synechiæ may be gradually torn by the action of the iris itself, but they may be at times the cause of frequent relapses of the disease. In these cases the careful use of a little sulphate of atropia in powder, applied with the usual caution to the eye, may forcibly tear them. Duboisine has been highly recommended for this purpose on account of its energetic action on the iris, or the alternate use of eserine and atropine may help to tear them. Streatfield proposed to tear them by passing a delicate blunt hook between the iris and lens (coreolysis), but there is great danger of injuring the lens during the operation. An iridectomy may prove in broad and obstinate synechiæ the best remedy. This is undoubtedly the case in complete exclusion and occlusion of the pupil. This operation is called for in such cases because the vision of the eye is almost entirely lost and because the communication between the posterior chamber, in which all the aqueous humor is formed, and chamber is abolished. The secretion going on in amber and increasing the tension of this part, will cause pressure on the iris and result in atrophy of this body, which at the same time will yield to the *vis-a-tergo* and will bulge out into the anterior chamber (bombé iris). The constant traction of broad synechiæ, but especially an exclusion of the whole pupil will also, if not relieved in time, by pulling on the ciliary body and choroid, lead to cyclitis or choroiditis (Fig. xxiii.), and even to atrophy of the eye ball and in unfortunate cases even to sympathetic ophthalmia and complete blindness. Iridectomy ought to be performed as soon as the inflammatory symptoms have subsided and ought to be made broad, by cutting out a large portion of the iris tissue, well up to its ciliary attachment and it may be repeated if the first artificial pupil made is filled up again by plastic material.

Operations on the iris may be called for in cases where the iris prolapsed, either through a wound or ulcer, causing an anterior synechia or staphyloma of the iris. A prolapse of the iris during an operation or after a recent injury is best replaced by rubbing the closed lids gently with our finger, but if in these cases the prolapsed portion cannot be made to retract, abcision of the prolapsing portion, and gentle pressure on the wound by means of a little horn spoon and the use of atropia or eserine, as the occasion may call for, (see page 91), may result in complete retraction of the iris; but more frequently an anterior synechia will remain, which may eventually require an iridectomy. At other times obstruction of vision may necessitate an operation on the iris. These may be opacities of the cornea, which are dense and will probably not clear up in the course of time, occlusion of the pupil, broad anterior or posterior synechiæ and opacities of the lens, that are not progressive. In these cases a new pupil can be made (1) by tearing off a piece of iris from its attached border (*Iridodialysis*), or (2) by drawing the pupillary border of the iris from behind the opacity and allowing it to heal into the periphery of the cornea (*Iridodesis* of Critchett); but these operations are often followed by serious complications and ought not to be performed except under peculiar circumstances. The best method is (3) the *iridectomy* as performed by Beer, 1805. This operation is not only made for the above mentioned obstructions of vision and to prevent the irritating action of posterior synechiæ, but it is also resorted to, in order to relieve the increased tension of the eye ball, in Glaucoma, for swelling of the lens in traumatic cataracts and for staphylomatous conditions of the cornea.

The operation of iridectomy consists in the opening of the anterior chamber by an incision in or a little behind the sclero-corneal margin, six to eight mm. long, according to the extent of the proposed new pupil, by means of the well known iridectomy knife or by means of a narrow cataract knife, which is the safer instrument in the hands of a non-expert, especially where the anterior chamber is very shallow. Care should be taken that the point of the knife goes through the cornea and enters the periphery of the anterior chamber; it is very easy to split the cornea and then it will be impossible to get a hold on the iris. Wounding the iris and lens is avoided by holding the knife in a horizontal position. The knife is to be slowly withdrawn after the incision is completed in order to prevent a prolapse of the iris into the wound. The iris is now grasped by means of the iris forceps as near to the ciliary border as possible, which is easily done by pressing gently on the scleral portion of the wound on introducing the forceps ; it is then drawn through the wound and abcised by means of a pair of curved iridectomy scissors. The abcision ought to be made by two cuts of the scissors, cutting first one side as near to the cornea as possible and then the other side, by turning the scissors in that direction ; the sphincter of the pupil is to be included in the cut and the cut edges of the sphincter are to be replaced by gently rubbing the edges of the wound with a little horn spoon, and all the blood, that may exude from the cut edges of the iris into the anterior chamber must be removed by means of a piece of linen pressed gently against the scleral margin of the wound. When this is accomplished put a few drops of atropia into the eye and bandage it carefully, and include in the bandage also the other eye, so that both eyes are kept perfectly quiet for at least two days after the operation , keep your patient in bed during this time and apply two drops of a two grain solution of atropia, night and morning to the eye. Should severe pain set in, the frequent use of warm water compresses, a couple of leeches to the temple, and atropia are indicated ; if little reaction follows the operation, let the patient get up after the second day, use a shade for both eyes, and atropia moderately for the operated eye a few days longer until all the symptoms of irritation have subsided. The point at which to make an iridectomy depends on the condition of the cornea, which must be perfectly clear over the new pupil, or it may depend on the opacity of the lens. The defect of the iris, caused by the operation, is called a coloboma of the iris. If possible make the new pupil upwards and inwards if made for visual purposes, or downwards if the upper lid comes down very low and the new pupil entirely. If the iridectomy is made , it may be made directly upwards. In very few cases can we expect to obtain perfectly normal vision after the operation. As the operation is very painful, ether should be given, the lids must be kept apart by a speculum and the eye ball fixed by means of fixation forceps, applied near the cornea in the conjunctiva, either near or directly opposite to the point of entrance of the knife. It must not be forgotten, that the cornea is a very hard tissue and that it requires a little force to penetrate it; if too much force is used, the knife may enter deeper than we anticipated and wound the iris or the lens.

Iridotomy means the cutting of bands of iris tissue in anterior synechiæ or he result of an iritis, after cataract extractio ne by an ordinary cataract needle, or a small ife, or by a delicate pair of scissors, which are introdu h a cut in the cornea.

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CHAPTER IX.

THE LENS.

THE lens is one of the most important parts of the dioptric apparatus. It is a perfectly transparent double convex body, whose posterior surface is more convex than the anterior. Its transverse diameter is about 8 mm., and its antero-posterior diameter between 4 and 5 mm., according to the age of the patient. It is held in place by the suspensory ligament of the lens (Zonula of Zinn,) which attaches it to the ciliary body. Its anterior surface is in close apposition to the iris, and its posterior surface rests in a cup-shaped depression of the hyaloid membrane of the vitreous body.

The lens is composed of the lens-capsule, the capsular epithelium and of lens-fibres.

The lens-capsule is a transparent sac, enclosing the lens proper, from which it is separated anteriorly by the endothelium. It is a structureless, elastic membrane, which if ruptured will roll itself up; its anterior portion is thicker than its posterior; no blood vessels enter its surface.

The capsular epithelium is a row of cells lying on the posterior surface of the anterior portion of the capsule, where they are kept in place by a small quantity of a cementing substance. The cells are hexagonal, have large nuclei and are flat in the centre and more cylindrical at the periphery. There are no cells on the posterior capsule.

The lens fibres are very numerous; they are arranged so as to form plates or laminæ, which in turn are arranged in such a way that they overlap each other and form three triangular segments, the points of which are in the centre, the bases toward the periphery of the lens. We have to distinguish between an outer, softer portion, the cortical substance and a smaller, harder portion, the nucleus, which however does not become apparent till the fortieth year. The lens fibres are long, flat, hexagonal in shape, generally with one nucleus. They have a tough peripheral, and a softer central portion. The latter is formed of myeline, and is called Liquor Morgagni. This is more abundant in the cortical portion, but less so in the central nuclear portion of the lens. The edges of the fibres are serrated and joined to the neighboring fibres in a manner resembling the sutures of the cranial bones. The individual fibres and the different layers are held together by a clear cementing substance.

The suspensory ligament of the lens surrounds its periphery like a folded band, the anterior layer of which extends over the edge of the anterior surface of the lens, the posterior layer to the posterior edge. It aids in the formation of the canal of Petit, connects the lens with the ciliary body and assists in retaining the former in place. Changes of the lens during life: In early childhood the lens is almost globular and very soft, later it becomes flatter and harder, and the nucleus becomes more distinct, till at last it can be easily separated from the softer cortical substance. The color likewise changes to an amber hue in old people, and the posterior surface becomes flatter than it was before.

The nutrition of the lens is accomplished through the intracapsular layer of epithelial cells and through the suspensory ligament of the lens.

The function of the lens is to bring the rays of light passing through it to a focus on the macula lutea of the retina. The lens is aided in this by the combined action of the cornea, the aqueous and the vitreous humors. These parts of the eye are called the dioptric apparatus, or the refractive media. If the eye is in a state of rest and parallel rays pass through it, they will come to a focus on the retina. But if the rays come from very near objects, they are divergent, instead of parallel, and would

They are caused either by injuries or by faulty nutrition or are due to senile changes. These opacities may affect certain portions of the lens only, as the capsule, or the nucleus or the cortical substance or the entire lens may become opaque. The changes in the nucleus causes it to become hard and brittle, its color to become dark brown, but retaining still a slight amount of transparency. The changes of the cortical substance produce a uniform gray mass more or less soft, which is composed of fragments of lens fibres, fat particles and cholesterine crystals.

Opacities of the lens are discovered by oblique illumination; by condensing the rays of light, by means of a convex lens on the eye. The pupil, which in the normal condition is perfectly black, appears now to be filled with a grayish white substance. On careful examination we find that this gray substance is not in the pupillary space itself, but that it is behind the iris and separated from the iris by a thin portion of clear transparent tissue, the capsule of the lens. If the distance between iris and opacity is greater, then we may conclude that the lens is not entirely paque, but that there is still some clear cortical matter. If the upil is widely dilated by means of atropine, we can examine the hole surface of the lens in this way. If the opacities are well dvanced, or are in the anterior and central portion of the lens, e may be able to see the gray reflex of the pupil with the aked eye. The most reliable means of diagnosis at our com- and is the ophthalmoscope. The slightest signs of a beginning taract appear like black spots on a red background if we ex- mine the eye with this instrument. As long as there is any d reflex through any portion of the lens, the cataract is not yet mplete. Opaque spots appear black, because they do not low the light to pass through them. Before the value of the hthalmoscope was known, the absence of a small inverted reflex age caused by the posterior capsule of the lens, indicating an aque condition of the lens anterior to the capsule and prevent- g the light from passing through it, was considered one of the ost reliable means of diagnosis. If the opacity is behind the sterior capsule, in the vitreous body for instance, this image ill be all the more distinct. In the normal condition of the e, we see besides this small inverted image of the light gener- ly used for such an examination, two erect images, one larger, hich is reflected from the cornea, and a smaller one reflected om the anterior capsule of the lens.

Any opaque spot in the eye is looked upon by many as a taract, but remembering that cataract is an opaque condition of the lens only, it will not be difficult to differentiate it from other opacities, especially with the aid of the ophthalmoscope and oblique illumination. A white opaque spot of the cornea is so much anterior to the iris, that it is almost impossible to mistake it for a lenticular opacity, especially if the oblique illumination be employed. More difficult is the diagnosis between a pupillary exudation or false pupillary membrane. If this exists, the periphery of the pupillary space or the entire pupil is filled with a dense white film varying in thickness. This film is seen to be on the same level as the iris itself, and it is almost always associated with immobility of the iris, so that atropia is not able to enlarge the pupil. This exudation mass glues the iris and the lens firmly together and will often lead to the formation of a cataract, by disturbing the nutrition of the lens. If in such a case the pupil has become free, only the exudation remains on the surface of the lens; this can be seen by oblique illumination as an elevation on the capsule, the lens itself often remaining perfectly clear. This condition is called spurious or false cataract. Opacities of the vitreous, if large and in the anterior portion, may give a gray reflex to the pupil; but the use of the ophthalmoscope will show that these opacities are far behind the plane of the iris, and that they are floating or shaking whenever the eye is moved.

Glaucoma gives to the pupil a greenish-gray reflex at times, but the ophthalmoscope will reveal more or less transparency of the lens. There are often corneal and vitreous opacities present in this disease, which may make the differential diagnosis

In the first place we have an opaque mass deposited on the anterior surface of the capsule. We have spoken of this before; it is called (1) *cataracta aggreata*, or spurious cataract.

The opacity may affect only a portion of the lens, for instance, the capsule (*cataracta capsularis*), or the nucleus only (*cataracta nuclearis*). Again, the extent of the opacity may be partial, (2) *cataracta partialis*, or it may be complete, (3) *cataracta totalis*. Of the partial opacities of the lens we have those that will always remain partial and those that are the beginning of a total cataract. If the latter is the case, the opacity is not so well defined, but appears in the form of spikes or irregular patches.

The permanent partial cataract, of which we have many forms, will not only remain unchanged, but the shape of the opacity is well defined and assumes different characters. Most of the varieties of cataracts are of this kind. The capsular cataract belongs to this group. We have an (4) *anterior capsular cataract* and a (5) *posterior capsular cataract*.

Capsular cataracts are either congenital or acquired. The anterior capsular cataract, if acquired, is either one of the sequelæ of iritis or keratitis. Masses of exudation in iritis, deposited on the capsule, may affect it to such an extent that after the absorption of the exudation, the capsule remains more or less opaque; or after a central perforating ulcer the lens will prolapse, and coming in contact with the wound may become adherent to it, later it may be freed by the formation of new aqueous and be restored to its normal position. During this time it may have suffered so much that an opaque condition of the capsule will be the result. The cornea will remain in these cases more or less opaque and will indicate the cause of the opacity in the lens. If during early life the exudation has become firmly united with the capsule of the lens and projects into the anterior chamber, it is called a (6) *cataracta pyramidalis*.

A congenital capsular cataract is a well defined grayish point that lies in the centre of the pupil; it is of the size of a small poppy seed, and is usually seen in both eyes. The cornea in these cases is perfectly clear; in the acquired it is cloudy or opaque. In some cases of senile cataract the anterior capsule becomes likewise affected. When this is the case, the cataract is seen to come in contact with the posterior surface of the iris, not separated from it by a clear zone, as is usually the case and is of a uniform gray appearance.

If the cortical substance of the lens is the seat of an opacity, this may be seen in the anterior or posterior portion of it. It is generally the beginning of a senile cataract, or it is caused by a diseased condition of the deeper structures of the eye. The (7) *anterior cortical cataract* begins generally at the periphery as a grayish zone or as fine striæ, and if central, it appears as irregular spikes, that soon cause more or less complete opacity and great impairment of vision. The peripheral opacities may exist for a long time without interfering with the vision of the patient; they may remain stationary and not be detected until failure of procuring suitable glasses or the rapidly increasing strength of the convex glasses required, may call for a careful ophthalmoscopic examination. On the application of atropia they are easily discovered.

Posterior opacities of the cortical substance are generally central (8), *posterior polar cataract*. They are frequently the result of great changes in the condition of the vitreous, and are frequently found in highly myopic eyes, associated with choroiditis, or they are the result of other choroidal or retinal affections. They are sometimes seen in retinitis pigmentosa. These cataracts appear as grayish opacities, far behind the plane of the iris, and are often stationary, or progress only very slowly. As they are behind the nodal point of the eye, which lies in the lens, they move in an opposite direction from that of the cornea, when the eye is moved. This is seen best by the ophthalmoscope. The opacity will move outwards if the patient is made to move the eye toward the nasal side, or it will move downwards if the patient looks upward, upwards if he looks down to the floor. They are not much benefited by treatment. The nucleus is more frequently the seat of opacities than the cortical substance. Such a condition is often a congenital deformity, but it may also develop later in life. We have several varieties of this trouble. We have a (9) *central lenticular cataract*, which is a well defined small grayish dot in the centre of the lens, similar in appearance to the congenital anterior capsular cataract. It causes little inconvenience to the patient, because, on account of its size, it does not interfere materially with vision. Children affected with it are often thought to be myopic. It is stationary, and is found generally in both eyes.

A larger variety of cataract is called (10) *zonular cataract*. This does not always affect the nucleus, but more frequently a layer or zone of cortical substance surrounding the nucleus, especially at the peripheral portion of it. It presents the appearance, when seen by the ophthalmoscope, of a dark ring on the red background of the eye, with a more or less clear centre, according to the implication of the nucleus or the location of the zone of opaque cortical substance. At times more than one zone is affected, and in such cases two, or even three, distinct black rings may be seen by ophthalmoscopic examination, one inside of the other. The nucleus is generally more or less affected. It is one of the rarer varieties of cataract, and is congenital or develops during early childhood, generally before the first year and mostly in consequence of convulsions and other diseases of infancy; it is probably caused by a disturbance of the anatomical arrangement or by a deficiency of nutrition. With very few exceptions they remain stationary, and affect generally both eyes.

The opacity is located deep behind the iris, especially if the opaque zone lies in the posterior half of the lens; it is therefore not clearly recognized except by the use of the ophthalmoscope, and if the zone is narrow, it will not interfere much with the sight of the patient; if it is dense and broad it will be more troublesome. With a moderately dilated pupil the patient gets very fair vision through the clear peripheral portion of the lens. He will therefore be almost blind in bright light, because his pupils become contracted, but will see better in the dark or if his back is turned to the light, in fact as soon as his pupil is dilated. In order to see better, such patients are apt to hold objects close to the eyes, and are therefore supposed to be near-sighted. But myopia is easily excluded, when we remember that near-sighted people are able to read the finest print; such patients, no matter how near they bring the letters to the eye, are only able to read very large print. Nystagmus is frequently present with this condition. If the nucleus is also opaque there may be but very little sight. As the patient sees with his pupil moderately dilated with atropia, he is greatly benefited by a mild solution of this drug, say one grain of atropia to two or four ounces of water, of which one drop is to be put into the eye every morning. The effect of the solution is to last from ten to twelve hours. This gives, of course, only temporary relief. But if on examining the eye we find the rest of the lens perfectly clear, no striæ extending from the opacity to the clear border of the lens, which is usually a sign of progressive cataract, a small iridectomy should be made in each eye, in a direction upwards and inwards. If the opacity is dense, especially in the centre, the cataract should be extracted, or be removed by the more tedious process of discision. The (11) *nuclear cataract* proper is hard in old persons, but is soft if occurring in young people. In the first case it is often the beginning of a total, senile cataract; in the second case it is usually caused by serious diseases, especially by diabetes; it grows very rapidly. It is different from the zonular cataract, because its centre is the most opaque portion, and not the periphery. With the ophthalmoscope the diagnosis is easy, especially if the zone is well marked.

We come now to the consideration of the *total cataracts*. They are of more importance, because they are of more frequent occurrence, and because they require surgical interference, on account of the defect in vision they produce.

We may divide these cataracts into three classes: traumatic, soft, and senile cataracts.

A (12) *traumatic cataract* is caused by a wound of the lens, or by an injury to the eye, which either produces direct concussion and disturbance of the anatomical arrangement of the lens, or causes changes in the relations of the zonula of Zinn, or the capsule, resulting in such lesions of the deeper portions of the eye, as will ultimately result in changes of the lens.

A direct injury of the lens may be caused by a sharp penetrating body like a needle, a piece of steel or a splinter of wood. They will generally pass through the cornea, causing a corneal wound, which will show later an opacity, indicating the mode of the injury. But the object might have taken an oblique direction, and penetrated the sclera; this may heal up so as to show but little of the original cause. Such wounds are, however, frequently accompanied with injury, and even adhesions of the iris to the corneal wound; in other cases the foreign body on its way to the lens may have passed through the pupillary space. As soon as the lens is wounded, it will begin to swell by the absorption of the aqueous humor; it will become opaque, sometimes in a few minutes after an injury, sometimes very slowly. In fact the opacity from an injury may remain limited to a small portion of the lens, but as a rule the whole lens will undergo great changes. With the swelling of the lens, which may last many weeks, we have more or less increase of pressure, and if this becomes very marked, pain is very apt to follow and may be very severe. If the lens capsule has been opened sufficiently by the injury, the lens will by its swelling begin soon to enlarge the wound of the capsule, and lens matter, more or less opaque, will fall into the anterior chamber.

Here it becomes gradually absorbed by the aqueous humor; more of the lens matter will fall through the opening, and in course of many weeks or months, the whole of the lens will be gradually absorbed. In children this process is accompanied with but little pain, and with only slight danger to the eye; the lens becomes rapidly absorbed. In adults, and especially in elderly persons, very violent symptoms may follow an injury of the lens. The lens begins to swell considerably, and even the whole anterior chamber may at times be full of débris of broken-up cortical matter. The pain and increase of tension of the eye become more marked. The iris will soon participate and become inflamed, either from the direct injury or from the pressure of the swollen lens on it. This will, of course, greatly increase the pain. The sight becomes almost immediately clouded, and the iris may form dense plastic adhesions with the capsule of the lens. This is, of course, a great drawback to a favorable recovery, and should be prevented if possible. The first thing, therefore, to be done after an injury of the eye, implicating either lens or iris, must be the free use of atropia, until a full dilation of the pupil has been obtained. The lens has now more space in which to swell, and can expand without causing much pain by its pressure on the iris. If the anterior chamber is full of broken-up lens matter, which may act here as a foreign body, irritating the iris, and especially if there is much increase of tension, a paracentesis of the cornea should be made at once, because the greatly increased intra-ocular pressure might cause lasting injury to the optic nerve. The paracentesis should in such a case be made with a broad iridectomy knife, and the knife must be withdrawn very slowly, allowing the aqueous and the débris of lens matter to flow out at the same time, and also to prevent a prolapse of the iris into the wound. The rest of the lens matter can be made to flow out by making gentle pressure on the peripheral portion of the corneal wound. It is not necessary, however, to remove all lens matter from the anterior chamber, because more will later again get into it, and unnecessary irritation of the eye should be avoided as much as possible. This little operation may be done without ether.

Gradually all the lens matter will become absorbed, leaving the pupil free, but the capsule will remain, and may, if it becomes opaque, necessitate another slight operation, iridotomy, on the eye. The eye is now without a lens, a condition known as *aphakia.* The patient may, by means of proper glasses, get fair sight again, but frequently the inflammatory action of the deeper parts, accompanying the absorption of the lens, have destroyed the chances for good vision materially.

A concussion of the lens, by a fall or a blow on the eye or head, especially if affecting eyes in which the nutrition of the lens is already slightly impaired—for instance, highly myopic eyes, or if the injury is accompanied by a great loss of blood, will often result in a gradual change of the transparency of the lens, with or without an inflammation of the iris or other portions of the eye. In such cases the eye may recover rapidly from the first injury, the "black eye" disappearing in a few days, when, perhaps months after the injury, the patient begins to notice that the sight of the eye has become slightly affected, and on examination the lens is now found to be slightly hazy. This will gradually deepen until the opacity becomes so great that the patient cannot see at all with the eye. This condition may develop at times from injuries near, but not directly affecting the eye, that are accompanied by profuse bleeding, for instance, after the extraction of a tooth. In such cases the cataract is perhaps caused by a disturbance of nutrition only.

Another class of injuries will affect the surrounding portion of the lens and cause opacity of it, by depriving it of its source of nutrition. Foremost of these are severe burns of the eye, especially in the region of the ciliary body, particularly if caused by lime. Deep and extensive injuries of the ciliary body will, among other changes of the eye, also result at times in the formation of a cataract, or the iris or choroid may have been the principal seat of the injury. In such cases the development of the cataract is apt to be slow, and may not appear until a very long time after the injury.

The treatment of these forms of cataract depends on the age of the patient. In young people discision, laceration of the capsule of the lens by means of a cataract needle, which will lead to a gradual absorption of the opaque lens mass, should be resorted to. In older people the extraction of the lens is the proper treatment.

As long as the other eye remains perfectly good, enabling the patient to attend to his work, an operation of this kind is not absolutely necessary, because after an operation, such an eye will be so much weaker than the other one, that it cannot be of much service to the patient, without the use of very strong glasses, and as long as the other eye is good it will not be convenient for the patient to wear these. The operation may, however, have to be done for the cosmetic result, because the opaque white lens will be the cause of a decided deformity and change in the patient's appearance.

In rare instances, the foreign body causing the injury may become lodged in the capsule of the lens without producing serious lesions of the lens. If this is the case, the pupil should be dilated by atropine, the anterior chamber of the eye opened carefully with an iridectomy knife, and the aqueous humor be allowed to escape slowly. A small pair of iris forceps are to be introduced now through the wound, the foreign body grasped and removed. If the foreign body is a piece of steel, its removal may be affected by a magnet, which is less liable to injure the capsule of the lens than the forceps. After this the eye is to be closed by a pressure bandage, and kept quiet for a short time. If the foreign body enters the capsule of the lens or gets into the lens itself, it may in very rare instances become imbedded without causing further injury to the rest of the lens, which may remain transparent, except immediately around the foreign body, where there will be some opacity. In most cases the opacity will spread and a total cataract will be the result. In such cases it is best to remove the foreign body with the lens, as the presence of the former might lead later to sympathetic affections of the other eye, especially if it should find its way through the lens to the ciliary body.

(13.) *Soft cataract, phacomalacia* (Fig. xxi.) is that condition in which the lens breaks down and forms a white pulpy mass, appearing as a perfectly uniform grayish mass, in which sometimes broad opalescent striæ or radii can be seen. It may occur as a congenital affection, (14) *congenital cataract*, or develop early in infancy or later in life, but it is generally that form of complete cataract that is found in young individuals. It is generally found in both eyes, and is often associated with other severe diseases of the eye, such as retinitis pigmentosa, myopia, or diseases of the choroid. The beginning of the opacity is generally seen in the posterior pole of the lens (see posterior polar cataract) and spreads rapidly over the entire lens. If this form of cataract develops after thirty years, the nucleus frequently remains hard, but before this period the mass is of uniformly soft consistency.

This variety of cataract is to be treated by discision, that is, laceration of the capsule. The soft contents of the lens become now mixed with the aqueous and will eventually become entirely absorbed. The operation is performed with a cataract needle, which has a small spear-shaped point, about two mm. long, a stem that is cylindrical for about ten or twelve mm., when it becomes of a larger diameter; this serves to close the corneal wound and prevents the escape of the aqueous, and gives us a better field for our operation. The eye should be thoroughly under the influence of atropia. The patient, especially if a child, should be etherized, the lids kept open by means of a speculum, the eyeball steadied by means of the fixation forceps, which are to be applied opposite to the point of entrance, and the stop needle is to be pushed through the cornea. The capsule of the lens is now divided by a single incision. We have to be careful, because we do not know how the eye will behave after the operation; a free division of the capsule might cause great swelling of the lens. An operation like this may have to be repeated several times until the whole cataract has been removed. If the eye has behaved well after the first operation, we may make the laceration of the capsule more extensive the second time. After the operation the patient is to be kept quiet, the eye is to be bandaged, and atropia and warm water applications are to be used several times a day, till the swelling of the lens subsides. A second operation can only be made after all inflammatory symptoms have subsided and the eye has returned to a perfectly quiet state.

Another form of cataract, (15) *diabetic cataract*, is found in persons of all ages that are suffering from diabetes. It is generally of the soft variety, has a milky-white appearance, and is very apt to undergo degenerative changes. It is caused by disturbed nutrition due to great density of the fluids around the lens, which is probably the result of the great drain of fluids from the system. It occurs generally in both eyes. It is to be operated upon by discision in young people, but by extraction if found in old people.

If the soft cataract is not operated upon, it is apt to undergo thinner, and may resemble a shell from which the fruit has been removed, (20) *cataracta siliquata*, or it may only form a thin white membrane, far behind the plane of the iris (21) *cataracta membranacea*. The absence of the lens which used to support the iris, causes it to be trembling whenever the eye is moved. Another form of soft cataract is found in older persons, between the age of forty and sixty, affecting especially the nucleus, and none or only a small portion of the cortical substance. The nucleus instead of being semi-transparent, and of an amber color, is now milky white. It occurs generally in very feeble, debilitated persons, and is very slow in development, or may remain almost stationary. An operation on such a cataract is not advisable: the results are far from satisfactory; it terminates generally in a phthisical condition of the eye.

We come now to the consideration of the most frequent and most important form of cataract, the (22) *senile cataract*. It is not the result of an injury or of an inflamed condition of the eye, but a degenerative process, caused perhaps, to a certain extent, by disturbed nutrition of the lens matter. All the softer parts of the body become more rigid with old age, and the process of endosmosis and exosmosis becomes more difficult.

As the nutrition of the lens is not derived directly from blood-vessels, such impairment of the soft membranes must result in faulty nutrition. The result, is a degenerative change; the individual lens fibres become harder, dryer, sclerosed, especially those of the nucleus. Liquor Morgagni is also found between the lens fibres, in the form of very small globules. The fibres are hard and have lost their hexagonal shape, and have become somewhat cylindrical, and have no serrated edges. When all the fibres have undergone this change, the cataract is mature. The cataract formed under this condition is apt to be a (23) *hard cataract*. Later the lens fibres will become finely granular, which will be followed, in the course of time, by a fatty degeneration. Fat globules and cholesterine crystals become mixed with the semi-fluid contents of the lens fibres, liquor Morgagni, and a milky appearance of the formerly gray-bluish cataract is the result. The cortical matter is more apt to break down and become more fluid; this is called a (24) *hypermature cataract*. The harder nucleus will eventually gravitate to the lower portion of the lens, and we are now able to see two different opacities, a whitish gray representing the corticalis, and at the lower portion of this, the darker colored nucleus, the edge of which may just reach the pupillary space, or if larger can be seen as soon as the pupil becomes dilated under the influence of atropine, (25) *cataracta Morgagniana.* The beginning of a senile cataract may take place at the centre of the nucleus, but also frequently in the cortical substance. It may begin peripherally in the extreme edge of the lens, as fine radiating striæ, (26) *gerontoxon lentis.* This will spread very slowly, and may remain stationary for a long time. At other times it will begin as large spikes or striæ, radiating toward the centre, and becoming broader, until the whole of the lens is implicated. If the cataract develops in this way, the broad opalescent striæ can be distinctly seen in the opaque mass. It denotes a soft condition of the cortical substance. The other mode of a beginning cataract is seen as a diffuse cloudiness of the lens, which gradually and more slowly than the striated opacities implicate the entire lens. This form results in a harder cataract of a uniform grayish color, through which the darker colored nucleus can be distinctly seen. At times the nucleus will become cataractous and opaque, while the cortical matter surrounding the nucleus, which in these cases becomes very large, remains transparent and clear. Under these conditions the pupillary space shows hardly any traces of opacity, and looks black, (27) *cataracta nigra.* On ophthalmoscopic examination the opacity is readily seen. If there are only a few opacities to be found in the lens matter, (28) *incipient cataract,* the patient complains of slight impairment of vision, especially for the distance, and as the opacities are frequently found in the centre, he can see better with a wide pupil, and therefore better on a cloudy than on a bright day; he sees better in the house than on the street, and he may be almost blind in the bright sunlight, on account of the narrow pupil, or on account of the diffusion of light caused by the opacities.

At times, when the opacities are in the shape of small spikes, patients complain of dark objects floating before their eyes; they see queer figures on the walls, or on the floor, or they see double, with the affected eye, *monocular diplopia.* They require very strong glasses to see with. If an old person requires to exchange his glasses frequently for stronger ones, we ought to be on the "lookout" for a cataract. All these opacities appear black if seen by the ophthalmoscope.

As the opacity advances the lens becomes swollen, pushing the iris forward and the anterior chamber becomes very narrow. The lens now looks bluish, and the vision of the patient is greatly reduced. This is called (29) *cataracta provecta.* The opacity advances now, and an opaque mass fills the entire pupillary space.

The cataract seems to be complete and the patient seems to see little or nothing, but there is still some swelling of the lens, and on careful examination we discover here and there spaces through which the reflex of the fundus can be seen; the cataract is therefore not quite ripe, (30) *cataracta immatura.* If the lens has become entirely opaque, and the intumescence of the lens has entirely subsided, we call the cataract ripe, (31) *cataracta matura.* This process may be rapid; it may be complete in a few months, or it may take years before the whole lens becomes opaque.

If a patient comes to us with a cataract, it becomes a matter of great importance to determine whether the cataract is ready for an operation, and what the chances of such an operation are, or whether it is advisable to operate at all. Let us try to answer the question. When is a cataract ready for operation? Whenever it is perfectly ripe, it is the best time to operate for it. How do we know whether the cataract is perfectly ripe, and what does ripe or mature mean? When the lens matter has become entirely opaque, and when it has separated from the capsule enclosing it. During the time a lens is becoming opaque, it swells considerably, the anterior chamber becomes narrowed, and the iris is carried forward. As soon as the cataract is mature, the swelling subsides, on account of a decrease in the volume of the lens, so that it becomes smaller than it was, and thus becomes loosened from its capsule. This decrease is caused by contraction, and by absorption of the superficial layer, and of the fluid contents of the lens. The iris retracts and the anterior chamber is restored to its natural size. We have, therefore, the following signs of a mature cataract: (1.) A complete opacity of the lens matter up to the capsule and to the periphery of the lens, so that even after the use of atropine, no clear portion of the lens can be discovered. (2.) The opacity has a yellowish hue, which is lighter if the cortical is more marked; darker, brownish if the nuclear opacity is more developed. (3.) The lens is not swollen and the anterior chamber is deeper. Again, (4) the lens is smaller than normal; it is therefore loosened from its capsule. Such a cataract is ready for an operation.

The question now arises, what are the chances of the operation; are they good or are they bad; is it advisable to operate now or is it better to wait?

The chances of the operation are good, if the cataract is the result of senile changes, and not caused by, nor complicated with, severe diseases of the eye. It is advisable to operate for it in such cases, because a similar change is apt to develop in the other eye. If there are already evidences of a beginning cataract of the other eye, the operation should not be delayed; but if the other eye is perfectly good, and the person comparatively young, it may be better to wait until this becomes also affected. The eye operated upon would be of little use to the patient without the use of strong glasses, and these cannot be worn when the other eye is sound, because they disturb the vision of the good eye.

It is, however, to be remembered, that a cataract, if not operated upon, will eventually undergo further degenerative changes, and thus offer a less favorable prognosis in case of subsequent operation, and that it is a great deformity, that ought to be removed, even if it is only for the cosmetic effect. How do we know whether a cataract that we are going to operate for, is not complicated with other diseases that might make the operation useless?

A (32) *complicated cataract* (Fig. xxii.) may be a cataract associated with a macula corneæ. The macula may be easily seen by oblique illumination. If it is not a very extensive opacity it will not be a very serious complication. There may also be the remains of an iritis, posterior synechiæ, or even pupillary exudation. These, if they have existed for a long time, should make us look carefully for disease of the choroid. If there be an occlusion of the pupil, an iridectomy ought to be made several months before an extraction of the cataract is attempted. Synechiæ become very distinct after the use of atropia (Fig. xxii.) They appear like black bands on a white background, and if they are small and few in number, they offer no obstacle to the operation, but if they are broad, an iridectomy must precede the extraction.

More serious are complications of the vitreous body, the choroid, the retina, and the optic nerve. As we cannot see the fundus of the eye, the diagnosis of these complications has to be based on the appearance of the other eye, or the ability of the diseased eye to distinguish light. Diseases of the choroid are often found in highly myopic eyes, and are frequently associated with a diseased state of the vitreous body, which becomes cloudy and very fluid. This will prove a source of great danger during an operation, for in case of rupture of the hyaloid, there would be a great and serious loss of vitreous. In case of retinal and optic nerve lesions, the sight would be apt to be lost entirely, or limited to certain portions of the eye only. Before we operate, we should test the cataractous eye in regard to this point. This is done by the use of a candle in a dark room. If the light of the candle is seen at a distance of more than four feet, the cataract is probably uncomplicated, and the perception of light is said to be good; perception is bad, when the light is only perceived when brought close to the eye. The eye is absolutely blind when the light is not seen at all. The patient must also have perfect projection. This is found to be the case if the patient, while he keeps his eye directed strictly forwards, is able to indicate exactly the direction of the light moved in various portions of the field of vision. The light must be held about eighteen inches away from the eye, and the patient should not be allowed to follow it with his eye, for if he did, it would only indicate good central vision. Any defect in the projection of light would be an indication of a seriously diseased condition of the posterior half of the eye, such as detachment of the retina, glaucoma, or choroidal changes. A want of perception of the upper portion of the field of vision, that is, if the patient does not see the light if held up in the air, and if the eye is at the same time soft, points to a detachment of the retina. If the light is not seen on the nasal side, there is probably glaucoma. This condition is called (33) *glaucomatous cataract.*

If all the conditions are favorable, and the health of the patient allows it, the cataract should be operated upon, because all the remedies that have been recommended for the removal of cataract have failed so far. Amongst these are iodide of potassium and electricity. But the improvement, if there has been any, from them, is due more to the improvement of the patient's general health, and his increased power of accommodation, than to a clearing up of the opacity. We may safely say that a cataract cannot be cured, but must be removed. During the development the patient's vision may be temporarily improved by a mild solution of atropia, if the opacity begins in the centre of the lens, and if on that account the patient sees better with a wider pupil; or by a solution of eserine, if the opacity is peripheral; and if the patient sees better through a narrow pupil. Such patients ought not to do fine work requiring a great strain of accommodation, as it might lead to affections of the choroid.

Of the operations for cataract, the modified Graefe's operation has thus far been most successful, and is the one employed by our best surgeons. It offers better chances of success than the flap operation, and is so much freer of danger than reclination or depression, that this is seldom resorted to now. Before operating, the patient's general health and his habits ought to be studied by the operator, and it is necessary that there should be no inflammatory action in the eye or its appendages. Those most frequently met with are affections of the conjunctiva and of the tear passages. The latter especially should be attended to before the operation is undertaken, as the foul, septic contents of the sac would be apt to infect the wound and poison it. The patient should be prepared for the operation by a slight cathartic given the day before the operation, so that he can remain perfectly quiet the first few days afterwards.

Reclination of a cataract is performed by means of a cataract needle. After the full dilatation of the pupil by means of atropia, the speculum is introduced, and the eyeball steadied by means of the fixation forceps; the needle is then introduced into the posterior chamber through the outer and lower portion of the sclera (about three mm. behind the cornea) in such a way that a longitudinal wound is produced. The needle is now pushed carefully to the upper and inner portion of the lens, and by lifting the handle lightly, the lens is dislocated and pressed downwards. The needle is carefully removed, and the eye closed by a pressure bandage. The patient has to keep in bed for several days.

This operation has the advantage of not disfiguring the eye and of being easily and quickly done, and that the effect is quick and generally satisfactory for a short time after the operation. But the dangers of the operation are very great; the lens becomes absorbed or encapsulated in a few cases, but it generally acts as a foreign body in the eye, and it will sooner or later, perhaps after many years, cause very painful inflammatory attacks of the eye, leading to secondary glaucoma, which will eventually produce blindness of the eye. It may even set up sympathetic inflammation of the fellow eye, and leave the patient entirely blind. The operation is therefore justly discarded, and is only used in the case of extremely old persons that are supposed not to be able to live much longer.

Flap operation. This used to be the most favored operation, but it has never been as successful as the linear extraction, and is now but seldom resorted to, except in cases where there is a large, hard nuclear cataract to be removed. After the eye has been brought under the influence of atropia, the lids are held apart by an assistant, and the eyeball is steadied by the fixation forceps. (1.) A Beer's cataract knife is now used to divide the lower half of the cornea, in a downward direction, so that the incision lies inside of the limbus. After the knife is withdrawn, the aqueous escapes. (2.) The patient is now directed to look upward; a cystotome is then introduced, and with it the anterior capsule is freely divided in all directions, care being taken not to touch the iris. (3.) This being accomplished, the patient is again made to look up, when the lens is apt to escape spontaneously, or after gentle pressure in the region of the lower lid. (4.) It is now necessary to remove all the remains of the cortical substance; this can be done by gently rubbing the upper lid with the finger, exerting at the same time slight pressure on the lower lid. If by this manœuvre the pupil does not become entirely free of cortical matter, a Daniel's spoon may be introduced, and the opaque matter removed. If the pupil is free and perfectly black, and the edges of the wound in good apposition, a pressure bandage is applied to both eyes. The patient has to be kept in bed in a dark room for several days. He must have only liquid food, and for the first few days all muscular efforts must be prohibited, as they might cause a rupture of the hyaline and escape of the vitreous humor, or cause at least gaping of the wound, and prevent its healing by first intension. The after treatment is like that of the following operation. This operation causes the total loss of ten per cent. of all eyes operated upon, mostly from panophthalmitis.

The modified linear extraction was introduced by A. von Graefe, in 1865. The great danger of a large corneal wound taking on ulcerative action, was avoided by making the incision in the sclera a little outside of the sclero-corneal junction, where it is more apt to heal, and where, on account of the large diameter of the circle, a smaller incision will suffice for the delivery of the lens. The other great danger of the flap operation, the wounding or bruising of the iris, which frequently gave rise to inflammatory attacks, was averted by making an iridectomy. Another great advantage of the operation is the peripheral incision which facilitates the delivery of the lens, and of the remaining cortical masses.

The operation may be divided into five sections: 1, the incision; 2, the iridectomy; 3, laceration of the capsule; 4, delivery of the lens; 5, removal of cortical matter, and cleaning the wound. The patient is to be placed in the bed in which he is to remain after the operation. His head must be slightly raised, and if the right eye is to be operated on, the operator has to stand or sit behind the patient; if it is the left eye, he is to sit on the edge of the bed in front of the patient, unless the surgeon is ambidextrous. No atropia is to be put into the patient's eye. After the introduction of the speculum, which should curve backwards, so as not to interfere with the operator's hand, the eyeball is to be steadied by seizing a fold of conjunctiva near the lower portion of the cornea, with the fixation forceps. (1.) A very narrow, long cataract knife (Noyes' modification) should now be taken, and before making the section, the upper two-fifths of the cornea should be measured off with the knife as a guide for the incision; this is to be made in the sclero-corneal margin. After the knife has entered the anterior chamber, its point must be directed to the centre of the pupil and the cutting edge upwards. After the pupil has been reached, the point must be elevated to a point opposite to the point of entrance, the counter-point, and the knife pushed through the sclero-corneal junction at this point. The incision is now to be carried to the upper portion of the cornea. Injury to the iris must be avoided if possible. (2.) After all bleeding has stopped, the fixation forceps must be given to an assistant, and the iris be drawn out of the wound by means of a pair of iris forceps and a moderately large piece of iris is to be cut off by means of a pair of iris scissors. Care must be taken that a piece of iris, reaching from the pupillary border to the periphery is removed. It is best to do this by two cuts of the scissors, holding the scissors as closely to the sclera as possible. The iris must now be replaced by rubbing the edge of the wound with a small horn spoon, or it may be replaced by means of a thin, hard rubber probe, so that the sphincter of the iris is perfectly free. A little blood from the iris is apt to get into the anterior chamber; this should be removed by pressing a little fine linen gently over the upper edge of the wound. (3.) The operator takes hold of the fixation forceps again, and if the anterior chamber is free of blood, lacerates the capsule; this is the next step. It is to be done by an instrument with a small cutting hook. The incision may be made freely over the anterior surface of the capsule, cutting out the central portion of it, or only at the periphery, in a line corresponding to the upper portion of the wound. (4.) After the capsule has been divided, the delivery of the lens may be accomplished by directing the patient to look downwards, or if he is etherized, by rolling the eye as far down as possible, exerting a little pressure at the same time, with the fixation forceps. If the lens does not escape immediately, a little pressure may be made on the lower portion of the cornea by means of a small horn spoon, and if necessary also on the upper portion of the wound, so as to make it gape. The lens will now escape, but if it does not do so, it can be removed by passing the little horn spoon behind it, and lifting it out of its bed.

(5.) In some cases, where the cortical substance is hard, it may scape with the nucleus, but if it is soft, a portion of it may remain in the capsule. This should be removed by a gentle rotary motion of the finger on the lower lid, or by pushing the lower id up toward the wound, exerting at the same time gentle pressure on the cornea. Or this may be done by the horn spoon applied directly to the lower part of the cornea. If this has been done, care must be taken to see that the iris is not caught in the wound and that there is no retained cortical substance in it, in order to ensure healing by first intension. After the conjunctival sac has been thoroughly cleansed with a mild solution of boracic acid, both eyes are to be bandaged, so as to secure rest. The speculum and the fixation forceps should now be removed from the eye before applying the bandage; dress the eyes with a circular piece of linen saturated in a solution of boracic acid; over this place a layer of very soft borated cotton, and over the whole, place the usual flannel bandage.

The complications of the operation are profuse hemorrhage into the anterior chamber during the first or second stage of the operation. This obscures the field of vision, and the blood must be removed by pressing fine linen over the wound. More serious is the escape of the vitreous humor during or after the delivery of the lens. If this takes place, the operation should be finished as rapidly as possible, even if a little cortical matter remains in the eye, and the eye be quickly bandaged and kept as quiet as possible. The most dangerous complication is a dislocation of the lens during the attempts to deliver it into the vitreous humor. If this occurs the lens must be removed from the eye by means of the horn spoon; and as there will always be some scape of vitreous, the operation should be finished as rapidly as ossible and the eye be bandaged.

After Treatment.—The patient's bed should be in a darkened oom, the dressings being made by candle-light. He must be ept perfectly quiet on his back, no excitement or muscular effort ould be allowed; he must not raise his head nor even his hands. he bandage should be removed within twenty-four hours after e operation, but the eye must not be opened at all. If there purulent discharge or blood, but no pain, the eye must be ished gently with a little boracic acid solution, and a little may allowed to get into the eye. This is not necessary if there is t much discharge. A new bandage must now be applied in e same manner as before. The bandage should be removed ery day, but the eye must not be opened. On the third or fourth day the fellow eye may be relieved of the bandage, but must be protected with a shade, and a drop of atropine must be put into the eye, which had been operated upon, daily after this to prevent the formation of synechiæ. On the seventh day the patient may leave his bed, and the bandage may then be removed from the eye operated on; at first, however, only for a short time, and a large shade covering both eyes must be worn in its stead. The bandage should be worn at night. We may now attempt to ascertain how much the patient can see, but must not try the eye too much, nor must we give him glasses too soon. It is seldom that glasses can be used sooner than four weeks after the operation. It is preferable to perform the operation without an anæsthetic, if the patient is able to control himself, since it obviates the disagreeable and dangerous vomiting after the operation. It is not advisable to operate on more than one eye at a time, even if both eyes have mature cataracts, because any accident occurring during the after treatment might affect and even destroy both eyes. If the first eye should not progress favorably, special care suited to the occasion, may then be given to the other eye.

Complications during the after treatment. There is but slight pain a few hours after the operation in a normal case, and this is caused by the escape of the aqueous humor, which will take place several times during the first eighteen or twenty-four hours, before the wound heals. After this there should be no pain, and no discharge to speak of, except tear fluid and a little mucus. If there is, however, at any time after the first day, severe pain in the eye, or if there is much discharge, a careful inspection of the eye should be made. We may find diseased conditions of the conjunctiva; these are generally not of much importance, and may be treated with a mild astringent and disinfectant lotion, such as boracic acid, gr. v to aq. ℥i. More frequently the conjunctival injection accompanies more serious troubles of the cornea or iris.

Corneal complications begin generally at the wound. The edges are not clear and transparent, but surrounded with a zone of infiltration which will lead to suppuration of the wound; this may progress more or less, and the cornea may break down, pus will be found in the anterior chamber and frequently in the vitreous, the iris and even the choroid will become implicated in the process, and the eye will be lost by panophthalmitis or plastic irido-cyclitis, ending in phthisis bulbi.

The first symptoms are noticed the second or third day;

there will be pain, but not very severe; œdema of the lids, especially of the free border of the upper lid, and some discharge, which is due to the inflamed state of the conjunctiva. The treatment of this complication consists in the use of hot water, applied as warm as the patient can bear it; it is to be used three or four times a day for at least half an hour at a time. After the use of the warm water, two drops of a solution of: atropia, grs. ii, boracic acid, grs. v to ℥ i of water should be instilled into the eye. During the intervals the bandage should be worn, and ten-grain doses of quinine, three times a day, should be ordered. This will sometimes check the process; the cornea will clear again, the hypopion disappears, and the patient may make a good recovery.

Complications of the iris are apt to show themselves about the fifth or sixth day after the operation. They are accompanied by severe pains, especially at night; there is no increase of the discharge and the corneal wound is perfectly clear, but there is conjunctival injection and marked œdema of the upper lid. The iris may not be changed much, but synechiæ will be noticed. There is great photophobia when the bandage is removed, thus rendering it difficult to examine the eye. The pain and the other symptoms may be greatly relieved by the use of two or three leeches to the temples, by applications of hot water, three or four times a day, and by the free use of atropia. The use of the bandage should be continued. The result of this iritis may be a plastic membrane which will fill up the newly made pupil and interfere with the patient's vision; it may even draw the whole iris to the wound. After all inflammatory symptoms have subsided, which may take several months, this false membrane may be divided and broken up by means of delicate scissors, or a cataract needle.

A cystoid cicatrization of the wound is sometimes caused by a prolapse of the iris into the wound, or by imperfect restoration of the edges of the iris after the extraction. The iris will appear as a little dark swelling in the corner of the wound. The constant traction of this on the iris sets up inflammatory attacks of the iris and choroid, or it may keep the eye irritable for some time. The bulging portion of the wound may be grasped by forceps and be cut off with scissors close to the edge of the wound. The capsule of the lens, which was left in the eye, may remain perfectly clear, but it is apt to become more or less opaque, even if a peripheral incision of the capsule has been made. This lessens also the danger produced by the rough edges of the large capsular wound. Such capsular opacities are generally in the shape of thin films. The vision of the patient, that had been good after the operation, now becomes more hazy and indistinct. This is called secondary cataract and forms generally several months after the operation. It may not be seen with the naked eye, but the striæ become very distinct when examined with the ophthalmoscope. This secondary cataract has to be divided. It is only a thin layer, but it is very hard and it is not easy to make a central opening through it. The operation is performed with a cataract needle. A crucial incision is made in the capsule, and it must be so deep that it reaches the vitreous; this will now prolapse and keep the edges of the wound apart. Even a small central opening thus obtained will generally improve the patient's vision considerably. Pupillary exudation, due to plastic iritis, may be operated upon in the same manner (*iridotomy*). If the iris be drawn into the wound, thus closing the pupillary space, the bands binding the iris down, may be divided with a cataract needle, or iridotomy scissors carefully introduced through a wound of the cornea; or an iridectomy may be made at a point opposite to the original wound, care being taken to excise a large central portion of the iris if possible.

Aphakia.—After the removal of the lens, the eye becomes very hypermetropic, and very strong convex glasses are necessary for good sight. Two different glasses are required, one corresponding to the strength of the lens when adjusted for the distance, and the other to equal the strength of the lens during the act of accommodation for near objects. This last one is of to look for this in the irregularities of the cornea, caused by the wound, and remains of other inflammatory processes, like synechiæ. Again, old people frequently have less acute sight than normal eyes. The absence of the lens, aphakia, is recognized by the fact (1) that the anterior chamber is very deep, (2) that the pupil is very dark, as there is no lens behind it; (3) that there is a trembling iris, *iridodonesis*, because the iris has lost its support. After an extraction with an iridectomy, this symptom is not so often present, because the edges of the iris are kept more or less tense in the wound; (4) the absence of the two reflex images of the anterior and posterior surface of the lens, there is only one large reflex image of the cornea present; (5) that the eye has become very hypermetropic, so that we are able to see the fundus readily with the ophthalmoscope some distance away from the eye, and by means of very strong convex glasses near by, and that the patient's vision is improved by very strong convex glasses (cataract glasses). Aphakia is usually the result of an operation, but the lens may also be lost after an injury, or it may be absent at birth, congenital aphakia.

Dislocation of the Lens, Luxatio lentis (Fig. xx.)—The lens is held in place, as we have seen, by means of the suspensory ligament of the lens at the periphery, by the vitreous behind and by the iris in front. It happens sometimes that the ligament of the lens becomes torn in consequence of a blow, or that it becomes stretched or diseased by severe diseases of the eye; for instance, in high degrees of myopia or choroiditis. In these conditions the lens may change its place spontaneously; slowly in the latter condition, suddenly and as the result of an injury in the former state. But a dislocation of the lens may also be congenital (*ectopia lentis*). In these cases it occurs generally in both eyes and is not very marked. The most frequent cause, however, is an injury. In these cases the lens may be dislocated entirely, and may be in the vitreous humor or in the anterior chamber, or it may be removed entirely from the eye, if a rupture of the eyeball takes place at the same time, and it may be found under the conjunctiva of the eyeball as a transparent tumor, the outlines of which can be distinctly seen, as soon as the accompanying ecchymosis subsides. The rupture of the eyeball in these cases is generally due to some large blunt body striking the eye with great force, such as a hand or a stone, and it is generally located in the sclera at a point opposite to where the eye was struck. The wound is usually about 3½ or 4 mm. from the corneal junction, and is accompanied by a large effusion of blood into the anterior chamber, swelling of the lids and chemosis. If the lens is in the anterior chamber (Fig. xx.) it can be easily seen, especially by oblique illumination. If it is dislocated into the vitreous, it may be difficult to see it, not only because the lens is transparent, but because it may lie entirely behind the iris, or because the vitreous becomes very cloudy under the circumstances.

If the lens cannot be seen in its new location, we have to depend upon other symptoms of a dislocation of the lens. There is, in the first place, (1) an iridodonesis or trembling iris, which is especially marked if the lens presses against a portion of the iris only. In the last case there is apt to be an (2) oval pupil after the use of atropia; (3) the anterior chamber is uneven, deeper at one side than at the other; (4) the fundus of the eye, if it is visible, can be seen through strong convex glasses; the eye has become hypermetropic; (5) by oblique illumination the outlines of the lens may be seen either in the pupillary space, after the use of atropia, if there is only a partial dislocation, or in the anterior chamber, or sometimes the dislocation is into the vitreous humor, (6) by means of the ophthalmoscope. The part of the pupil, not covered by the lens, looks more brilliantly red than the other portion, which is often separated from it by the darker periphery of the lens. There is in some cases monocular diplopia. This is explained by the fact that some rays do not pass through the lens at all; the rest pass through the edge of the lens, which acts as a prism.

CHAPTER X.

THE VITREOUS HUMOR.

The posterior portion of the eyeball is filled with a clear, transparent substance of gelatinous consistency, called the vitreous body, which is enclosed in a perfectly clear hyaline structureless sac, called the hyaloid membrane. This sac is flattened in front, where it has also a cup-shaped depression for the lens to rest in, called the fossa hyaloidea; behind it is, according to the shape of the eye, more or less globular. Its antero-posterior diameter is about 13 to 15 mm.

Posteriorly this sac rests on the retina and is slightly attached to the optic papilla. Anteriorly it is in close relation to the lens and also to the suspensory ligament of the lens.

The vitreous body is divided by septa and contains cells of different shape; they are more numerous at the periphery than towards the centre; the centre is occupied by a canal, the hyaloid canal, running from the posterior portion near the centre of the optic papilla to the cup-shaped depression in front. This canal is occupied by a nutrient vessel, the hyaloid artery during fœtal life. In very rare cases the vessel remains permanent, and is seen in such cases by means of the ophthalmoscope as an irregular black line, running from the optic-papilla forwards to the posterior surface of the lens. The hyaloid membrane is supposed by many to be merely a tougher and denser portion of the vitreous humor. The vitreous is devoid of blood-vessels and nerves and receives its nutrition from the ciliary body and retina. Inflammatory actions in the vitreous body do not occur idiopathically, but have their origin in the surrounding parts, especially in the choroid, or in the iris, or in the ciliary body. The inflammatory products of these diseases are apt to be found in the vitreous body, where they can be easily studied on account of the transparency of this substance.

Serous infiltration of the vitreous body, caused by chronic diseases of the ureal tract, will lead to such changes in the vitreous body, that it may become as liquid as water; this is called *Synchisis.*

The most frequent cause of this trouble is that form of choroiditis which we are apt to find in connection with old injuries of the eye with syphilis or with broad synechiæ or especially after occlusion of the pupil and also in highly myopic eyes. In such cases we have often increase of the ocular tension; the eye-ball feels hard and the vision is greatly reduced. It is also met with in severe cases of iritis and cyclitis and is in these cases associated with a more or less hazy condition of the anterior portion of the vitreous, caused by the migration of wandering cells of the inflamed parts into the vitreous; they reduce the vision of the patient considerably. The increase of tension is but slight in such cases. In very chronic cases of this affection we may find numerous bright yellow crystals of cholesterine floating in the vitreous. *Synchisis scintillans.* — Later synchisis may lead to trembling of the iris and even to a dislocation of the lens.

Plastic infiltration of the vitreous humor occurs frequently in cases of plastic cyclitis, glaucoma and especially in choroiditis disseminata, but also in diseased conditions of the retina and the optic nerve. It is also seen after injuries, after the entrance of foreign bodies or after hemorrhages into the vitreous. It is principally due to a migration of round cells and to an exudation of a fibrous coagulum. These will cause in the beginning a more or less diffuse cloudiness, which by the patients is compared to a cloud coming over their eyes; later contraction of the exudation body and it may be more marked at one time than at another (Glaucoma).

The latter variety is seen as a floating black substance on the red back ground, especially when the patient is told to move his eye. They may interfere with the vision considerably if they are fixed, central and membranous, at other times they may be seen only when the patient is moving his eye or shaking his head ; if the patient keeps quiet, the opacities may sink to the bottom of the eye and the vision may become almost normal.

This disturbance of vision is what the patients are apt to complain about ; the floating objects appear to the patient to be outside of the eye and he is often trying to remove the disturbance they create by his hands, till he becomes aware of their true nature. They are especially distinct in bright lights, and if the patient is looking at a white object. Another variety is seen in old people, with other senile changes, as a small thin, fixed opacity, irregular in shape and almost transparent, so that it is very hard to discover them ; the vitreous is not changed, and they are not floating, nor are they preceded or accompanied by inflammatory symptoms and give no further trouble except by the presence of a small spot in the field of vision of the patient, especially in reading or sewing. This variety does not seem to be influenced by treatment to any extent. Dry cups to the temples and the use of iodide of potassium have been recommended. Vitreous opacities should be treated by attention to the original disease that gave rise to them and by the occasional use of the artificial leech, applied to the temples twice a week, taking, according to the strength of the patient, from a quarter of an ounce to an ounce of blood at a time. A steam bath, local or general, is often of great service. Electricity, especially the galvanic current, has also been used. Firmly organized opacities are difficult to cure ; they should be treated by the use of mild doses of the bichloride of hydrargyrum combined with iodide of potassium.

Purulent infiltration of the vitreous is caused by an injury, by purulent iritis or by a purulent process of the ciliary body or choroid : the pus cells are collected in certain parts of the vitreous humor, giving this a cloudy, yellowish appearance, or they will invade the whole vitreous body. This is easily broken down and in a very short time the vitreous may be changed into a purulent mass ; in this condition it may lead to a perforation of the eyeball. The process, however, may become chronic and lead to a formation of connective tissue in the vitreous, which is generally mpanied by a marked increase of tension ; it may resemble a sarcomatous tumor, but this is much slower in its development. Later, contraction of the newly formed tissue within the eye will take place, which will cause not only a great shrinking of the eyeball, but also great reduction of the intra-ocular tension of the eye; this becomes so soft that by the traction of the four recti muscles the eye-ball no longer remains round, but assumes a quadrangular shape, *Phthisis bulbi.* Such an eye will never recover its vision.

Hemorrhages into the vitreous are usually the result of an injury, such for instance as a blow with the fist on the eye or orbital margin, but they may also occur spontaneously. It is sometimes caused by a sudden reduction of intra-ocular pressure, after an iridectomy in glaucoma, or if there is much loss of vitreous in operations or injuries of the eye, congestion of the choroid and various other diseases may give rise to it. The blood may fill only part of the vitreous after penetrating injuries, or it may fill the whole interior of the eyeball, the vitreous and the anterior chamber, (*hæmophthalmus*). Such injuries are frequently accompanied by a dislocation of the lens. The blood may be diffused, or it may be in coagula at the bottom of the eye. The fundus cannot be seen in these cases; the whole mass appears black and by oblique illumination dark red.

The vision of the patient is naturally very much impaired, but he generally sees objects as if a red or a dark cloud was before his eyes; he has perception of light at all times.

The blood which is derived from the blood-vessels of the lating applications of arnica and warm water are called for. If there are any opacities remaining, the use of iodide of potassium, fifteen grains twice a day, may be of good service.

Foreign bodies in the vitreous.—The entrance of a foreign body into the vitreous is always a very dangerous injury; if the foreign body passes through the cornea, it will in most cases injure the iris and the lens likewise; if it enters very obliquely the lens may be avoided; if it finds its way through the sclera, it is apt to cause injury of the ciliary body resulting in cyclitis, further back it will have to pass through the choroid. In the most fortunate cases, where these tissues do not take on inflammatory action, the presence of the foreign body is nevertheless a source of great danger; it may set up inflammation of the vitreous. The cells migrate in such a case in the channel made by the passage of the foreign body, or the latter may, by its pressure on the retina, but especially on the ciliary body, set up irritation of the fellow eye, leading to its total destruction. Even in very favorable cases, where the foreign body becomes encapsulated, it may from very slight causes become liberated and press on and irritate some vital portion of the eye, causing destructive inflammation. The principal point in such accidents must therefore be the removal of the foreign body. This is in most cases a piece of iron or steel from the hammer of the mechanic; but pieces of other kinds of metal, stones, wood, or shot may enter the eye; fragments of glass are especially dangerous, since on account of their transparency it is difficult to detect them. The opacity of the vitreous, caused by the presence of a foreign body, varies according to the size of the body and to the quantity of blood that escaped into the vitreous at the same time. It may therefore not be easy to discover the presence of the foreign body in the eye, especially as it might have passed through the eye-ball and rest in the orbit. With the exception of shots this is however not often the case, and we may be able to see the foreign body in the vitreous in many instances by means of the ophthalmoscope. If we find in a case of such injury a point of entrance in the cornea with a prolapse of the iris or the formation of a traumatic cataract, it is more than likely that the foreign body is in the eye. If the point of entrance is in the sclera and the vitreous opaque, attempts may be made to probe the wound very carefully, first at the opening and later a short distance in the vitreous body. If however this is of no avail, we may be able to determine the presence of the foreign body in the eye by perception of it by the patient. Let the patient look through a pin hole in a card, which is held half an inch from the eye and he may be able to see the foreign body as a dark mass, if it is not too small. After the foreign body has become encapsuled, it may be discovered by means of the ophthalmoscope, and in gunshot wounds, the point of entrance and also that of exit may be found in the choroid.

Treatment.—The principal part of this is the removal, of the cause which ought to be tried carefully and perseveringly on account of the danger which the presence of a foreign body causes to the vision of both eyes. If it can be felt in the scleral wound it should be grasped with a pair of iris forceps and carefully removed. If it is known to be a piece of iron or steel, a powerful magnet may be of great service in the removal of it. The magnets, which are made for this purpose, have a long blunt point, which must be introduced into the wound and carefully moved along the edge of it; if this fails, it may be passed through the wound into the eye, searching for the foreign body along the walls of the wound and for some distance in the vitreous body; it may be necessary to enlarge the scleral wound a little or to open the sclera at a point as nearly opposite to the entrance as possible and in a direction that the foreign body has probably taken. This is, however, only successful in comparatively recent cases; if the foreign body has been in the eye for some time and become encapsulated, it is next to impossible to remove it by a magnet. There is frequently a loss of some vitreous during these attempts, but this is not of great danger. If the foreign body entered through the cornea and projects through the iris, ating little dots or as strings of pearls or are of various s; they do not denote a diseased condition, and may ap- in perfectly healthy eyes. They are sometimes met with in ns addicted to self-abuse, more frequently in myopic eyes, ially those with a posterior staphyloma, or they accompany congestions of the head. They may cause anxiety to the nt; they are, however, no indication of danger, as long as no ges in the transparency of the vitreous can be seen by means e ophthalmoscope. The use of mineral waters or cream of , and slightly smoke-colored glasses give great relief in most ese cases.

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CHAPTER XI.

THE CILIARY BODY.

THE ciliary body is a vascular tissue, but it is also abundantly supplied by nerves; it connects the iris with the choroid, with which it is continuous at the ora serrata behind, where it is also connected with the retina; in front it is attached to the sclera, and is connected by means of the ligamentum pectinatum with Descemet's membrane. With the iris it is continuous through its stroma, blood-vessels and nerves. In fact its tissue consists of the same elements as the iris; the cellular element is about the same except that the stroma cells do not contain so much pigment as those of the iris, (with the exception of those of the negro) and that the elastic and connective tissue fibres are more abundant than in the former. Of great importance is the muscular element of the ciliary body; it occupies chiefly the most anterior and external portion, and is composed of longitudinal and circular fibres: however they do not act as opponents as those of the iris do, but acting at the same time and taking their fixed point at the scleral attachment, they draw the posterior portion of the interior of the eye forwards; this relaxes the suspensory ligament of the lens and allows the latter to assume a more globular form: the iris is at the same time drawn forwards. This is called accommodation. According to the amount of accommodative efforts required by an eye, the muscular tissue, especially the circular fibres, is more developed (hypermetropia) than in an eye that does not require so much accommodation (myopia): here the longitudinal fibres predominate. The circular fibres are located more in the inner portion of the ciliary body, the longitudinal ones lie nearer to the sclera; but they are not distinctly separated, they are frequently interlaced with each other.

The different layers of the ciliary body are similar to those of the iris. On the scleral surface lies a delicate layer of epithelial cells, then follow muscular fibres and the stroma proper; next to this is a thin elastic lamina and next to this is the uveal or pigmentary layer. On the inner side of this layer we have however, addition, the pars ciliaris retinæ, a continuation of some of the inal fibres. The inner side differs from that of the iris also by fact that it is uneven; it has a large number of elevations, ciliary processes, and a corresponding number of depressions. e ciliary processes are very vascular; they give attachment to Zonula of Zinn and are important in regard to the nutrition he lens and vitreous body.

The blood-vessels of the ciliary body are derived from the long posterior, and from the numerous anterior ciliary ar- es; these form an extensive network of vessels. The veins connected with those of the cornea and conjunctiva and h the venæ vorticosæ. The nerves are abundant; they are ciliary nerves and lie especially on the outer side, near the ra.

As the ciliary nerves play such an important rôle in the fol- ing chapter, I will give here a short anatomical description hem. The ciliary ganglion is a small flat lenticular body, that in the orbit between the optic nerve and the external rectus scle. It receives on its posterior border branches of three dif- nt nerves, called the roots; the largest one is the sensitive t and is derived from the naso-ciliary branch of the fifth ve; another smaller one is the motor-root; it is derived from ranch of the third nerve, that goes to the inferior oblique cle; the third is a sympathetic branch and is formed by fila- ts coming from the plexus surrounding the internal carotid ry. On the anterior border of the ganglion we find emerging it the ciliary nerves, fifteen to twenty in number; they run ard and perforating the sclera near the entrance of the optic e, they advance through grooves on the inner surface of the a until they reach the ciliary body where they divide and an extensive network of nerve fibres. Numerous branches given off to the choroid after the nerves perforate the sclera. r the branch to the ciliary ganglion has been given off, one ree small branches are sent by the naso-ciliary nerve directly e eye ball, which perforate the sclera in the same region as other nerves; these are the long ciliary nerves.

s is seen by this description, the ciliary body is in the most nate relation to all the important parts of the eye, and any y or disease of it is apt to lead to the most serious complica- ; but on account of its protected position it is seldom pri- ly affected. As the ciliary body supplies also the nutrition e lens and the vitreous humor, these parts are very apt to r from changes going on in it; these may lead therefore indirectly to the formation of a cataract, or to atrophic changes of the vitreous body.

Cyclitis.—Inflammatory processes in the ciliary body may be accompanied by products of a serous, plastic or purulent nature. They are generally caused by an extension of an inflammatory action in the iris to the ciliary body, but they occur also as complications of diseases of the choroid and cornea. Traumatism is likewise apt to cause inflammation of the ciliary body of the most dangerous kind, either by the wounding of it or by the irritation which is caused by the presence of a penetrating foreign body. Idiopathic inflammations are comparatively rare; they may occur after severe debilitating fevers, in rheumatism, syphilis or in scrofulosis.

As the ciliary body is abundantly supplied by blood-vessels and nerves, disturbances in the vascularity and pain must necessarily be the most marked symptoms of a cyclitis. In regard to the condition of the vascularity, this is not only found in the ciliary region of the episcleral tissue, ciliary injection, but the iris is likewise intensely congested, especially the veins can be seen at times as large tortuous vessels in the iris tissue. The ciliary injection is generally very marked and well defined and gives such eyes a very peculiar appearance, the region around the cornea being decidedly red and the rest of the eye but moderately injected. Cyclitis is frequently found to attack only a certain limited portion of the ciliary body; in the region of these patches, the ciliary injection is generally more marked, in some cases it may be limited to them; they vary in size and location, and are more frequent in the upper than in the lower half. The pain is not only very intense and located by the patient deep in the eyeball, and extending in the region of the supra- and infra-orbital nerves to the entire side of the head, but such an eye is also very sensitive to the touch, especially over the affected region. Even in cases where pain and injection are but moderately marked, the peculiar sensitiveness of the affected portion is so manifest, that it is one of the most valuable symptoms of a cyclitis. If the patient is directed to look downwards and we touch the eye through the upper lid gently with our finger, we will find that the moment this diseased tender spot is reached, the patient will throw his head back, suddenly and in a peculiar jerky manner, characteristic of this disease, complaining at the same time of sharp pain. Another symptom is disturbed vision, which is due especially to disturbances of the vitreous and complications of the iris, such as posterior synechiæ.

A serous cyclitis is characterized by serous effusions which will find their way into the anterior chamber or into the vitreous humor; it may be caused by a low state of the system or it is due to a long continued irritation of the ciliary body; it is however almost always combined with serous iritis or choroiditis and does not differ in its causes or symptoms from these affections. We find however cases where the characteristic deposits on the membrane of Descemet is quite marked without the iris being affected in the beginning; but there is always the peculiar well defined ciliary injection and some swelling in the region of the affected portion of the ciliary body; this may disappear after everal weeks, leaving a more or less marked bluish condition of he sclera and also posterior synechiæ of the iris. As the disease is prone to frequent relapses, it may result in great changes of the eye; extensive posterior synechiæ and staphylomatous bulgings or bluish spots of the thinned sclera, with greatly reduced vision and more or less severe corneal complications may be the result. This form of the disease is apt to attack young persons of a strumous diathesis or of a weak constitution. It may be caused in some instances by the irritation of a foreign body in the eye, or a dislocated lens and may lead in these cases to glaucomatous degeneration.

The treatment of serous cyclitis is confined to the most careful protection of the eye from irritating influences; all accommodative efforts of the other eye should be strictly forbidden; blue glasses must be worn by the patient. Atropine in most cases will be of great benefit, especially if the trouble is associated with iritis. Dry warm applications, such as a hot hop-bag applied to the eye, or warm water applications will give great comfort and relief to the patient. Blisters behind the ear are of benefit in very chronic cases. In more acute cases an artificial leech may be of great service, especially if there is disease of the choroid present at the same time; in these cases the moderate use of iodide of potassium and tonics is called for. ℞. Pot. iod. ℥ss; tinct. card. comp., tinct. gent. comp., syrupi zingib. āā ℥i. D. S.—ʒj three times a day. In scrofulous cases cod-liver oil and syrup of iodide of iron has been recommended. Only in those cases where there are corneal complications, calomel or the red oxide of mercury ointment, applied locally twice a week, is to be used.

Plastic cyclitis is even a more serious affection than the preceding variety, and is of more frequent occurrence. The plastic material, thrown out as a result of the inflammation, is found especially in the vitreous, causing great and dense cloudiness of the vitreous, especially of the anterior portion of it, or it is found as a dense white mass of fibrinous exudation, surrounding the ciliary body, or it occupies the posterior chamber, gluing the periphery of the lens and iris firmly together and leaving the pupillary portion of the iris perhaps entirely free; if the exudation is not readily absorbed, this will lead to serious consequences. The iris will under these circumstances dilate only partly after the use of atropine. By the contraction of the exudative material, which takes place later, the iris will be drawn backward and the anterior chamber will become deeper. In other cases the iris may participate and complete synechiæ or even occlusion of the pupil may be the result. The nutrition of the lens and the vitreous body will be greatly impaired; the vitreous may become less and of great fluidity which is characterized by a very soft condition of the eyeball, due to reduced intra-ocular tension. Later detachment of the retina or the formation of a posterior polar cataract may follow. The disease is frequently complicated with iritis, or it follows and aggravates a case of iritis. The exudation mass may become organized and contain blood-vessels and cells (connective tissue change). The tissue of the ciliary body itself becomes infiltrated with cells, formed by proliferation. Hemorrhages into the stroma of the ciliary body or into the anterior chamber (*hyphaema*) are often observed. The final result of the disease is frequently phthisis bulbi, which in some cases develops rapidly, but in others may take several years.

The symptoms of the disease vary according to the nature of the inflammatory process; there is great impairment of vision from the very beginning, due to dense opacities of the vitreous; the iris will dilate only moderately or not at all on account of the adhesions; there is ciliary injection and great pain and tenderness at the seat of the inflammation; if there is a foreign body present the region where this lies is exceedingly sensitive to the touch. A probe passed gently over the closed eyelids will soon reveal the spot, the patient will draw his head back as soon as the seat of the disease is touched. There is also great photophobia, so that it may be difficult to examine the eye.

The most frequent cause of a plastic cyclitis is an injury of the ciliary body, sometimes brought about by an operation, hence the cause of many failures after cataract extractions; or it is the result of wounds caused by penetrating foreign bodies, and the presence of these foreign bodies in the ciliary region is especially dangerous. These substances may have been in the eye for some time, perhaps encysted in one of the deeper structures and may have done no harm, but if from some cause or another they are liberated and press on the ciliary body, they will surely do mischief. Wounds in the sclero-corneal region are the most dangerous. This region has been justly called the "dangerous zone" (Nettleship). Wounds in other regions of the eye, associated with a prolapse of the iris or the ciliary body or the choroid, are also dangerous, in fact, any adhesion of the iris or the ciliary body may give rise to cyclitis on account of the constant traction to which they will subject the whole uveal tract, especially during accommodative efforts. It is also found after other severe injuries to the eye. I have seen it develop after a patient had been struck by lightning. Syphilis is likewise apt to cause it, and it may be due at times to diseases of the fellow eye (sympathetic ophthalmia). The disease may affect children, but it is generally a disease of later years.

Differential diagnosis. From an iritis it is differentiated by the great tenderness to the touch of the patch of the diseased ciliary body, by a more intense, localized ciliary injection and great impairment of sight. From a choroiditis by the tenderness and the ciliary injection. From an episcleritis by the great impairment of vision, which in this disease is not affected.

Treatment.—Atropia has to be used on account of its effect on the ciliary vessels and on account of its anodyne properties, but it frequently fails to give relief. It should be used in a two-grain solution, three or four times a day, especially after the use of hot water applications. These latter as well as a local vapor bath are of great service; they should be applied also during the early stages of the disease, even if this is the result of an injury. (Before an inflammation has set in, the use of ice is called for in traumatism). Mercury is of the greatest value in the treatment of the disease, especially during the later stages of it. It should be given in moderate doses; use of the gray ointment, ten to fifteen grains daily, applied to the feet, or the oleate of mercury. Iodide of potassium, five to fifteen grains three times a day, should be given in other cases where mercury is not advisable. Of the greatest importance is it to watch the state of the intra-ocular tension; if there is a marked increase of it, a broad iridectomy should be made. Perfect rest of both eyes is necessary and blue glasses should be worn. Leeches are also of great service.

Purulent Cyclitis is usually the result of an extension of a purulent affection of the choroid, in panophthalmitis (Fig. xxiv.) but it may also occur primarily after an extensive injury of the ciliary body, for instance after linear cataract operations, if the line of incision has been made too far in the sclera; after reclination of a cataract, or it may develop after a plastic cyclitis and it may be caused by the presence of a foreign body.

After a short period of congestion the rapid formation of pus cells is noticed; this may be confined to the inner portion of the ciliary body in the beginning, but soon the whole tissue becomes affected. The nerves and the muscular fibres are the last to break down and they may resist long enough in some cases, until the progress of the disease has been checked. The vitreous body is always likewise affected and later the iris and the other parts of the eye will participate in the process.

Treatment.—In the very beginning of the disease, especially if it follows an injury or an operation, energetic antiphlogistic remedies should be used. Ice-cold applications must be made and renewed every two or three minutes; four to six leeches should be applied to the temporal region and a mild saline cathartic may be given. If this fails, and during the later stages of the disease, warm applications should be made to hasten the breaking down of the infiltrated tissue or assist in the absorption of the pus cells.

Wounds and Injuries of the Ciliary Body.—Any injury of the eyeball, especially if a perforating wound may become serious; it may give rise to an inflammation, that before it can be controlled, may have done irrepairable injury to the eye. But the most dangerous of all injuries of the eye are those of the ciliary body. We have seen that this tissue is in direct contact with nearly all the important parts of the eye, that on it depends the nutrition of the lens as well as the nutrition and regeneration of the vitreous and aqueous humors. But even more important than this is the intimate relation of the ciliary nerves to those of the fellow eye.

Injury of the ciliary body may be the result of a penetrating wound, caused by a sharp object. The most dangerous of these wounds are those in the region of a zone of the sclera within 3 mm. from the sclero-corneal junction. Any operation therefore, for instance for cataract or an iridectomy, in which the line of incision has been laid in this zone, is apt to be followed by serious consequences. Such incisions should therefore be as much as possible in the sclero-corneal junction and rather nearer to the cornea than to the sclera. The danger of these is increased if it is not a clean cut, but a more or less irregular one or a laceration. Such wounds will often lead to plastic cyclitis and even to sympathetic affections of the fellow eye. The injury may be caused by a penetrating foreign body, and if this remains in the wound or in the ciliary body, it is exceedingly dangerous, because we do not only have a laceration to deal with, but the presence of the foreign body is also continually adding to the irritation, and it is the exception that a foreign body becomes encapsulated in this region without having caused serious injury to the one or even to both eyes. Even after it becomes surrounded and enveloped by plastic material it may become detached after many years of quiescence and cause great damage. Even if it does not lead to affections of the other eye, injuries of the ciliary body are apt to cause degenerative changes of the injured eye (Phthisis bulbi).

Contusions of the ciliary body are comparatively rare, because it occupies a protected position ; if severe, they are apt to lead to serous or plastic cyclitis and may lead eventually to the formation of a traumatic cataract or even to degenerative changes of the vitreous body ; the eyeball will become soft and phthisical. Sympathetic affections of the other eye are however comparatively rare sequelæ, except when the Zonula of Zinn had been ruptured at the same time.

Burns of the ciliary body are frequently caused by such caustic substances that have a tendency to penetrate the superficial tissues and of these lime is perhaps the most dangerous. We may have even a comparatively small burn of lime with but little or no complication of the cornea, and may congratulate ourselves, when after a short time the conjunctival wound heals without hardly any cicatrisation, and may have discharged the patient as cured ; when after a lapse of several months he returns with the complaint of failing sight in the injured eye. On examination of the eye we may be surprised to see that a traumatic cataract has developed. If a large portion of the ciliary body has been injured by the burn, the formation of a cataract and even softening of the eye, due to vitreous changes, may result very rapidly.

The treatment of any injury of the ciliary body should consist of (1) removal of any foreign body that may be in or near the wound, and for this purpose a magnet or a pair of very delicate iris forceps may be of great service. Care should, however, be taken to disturb the rest of the ciliary body as little as possible. (2) The edges of the wound should be cleaned very carefully and all prolapsing portions of the ciliary body should be carefully removed and cut off. The use of sutures in this region should be avoided. (3) Cold is of great service immediately or shortly after an injury to prevent inflammation. It should be steadily applied night and day for thirty-six or forty-eight hours after the occurrence of the injury. (4) Absolute rest of the injured as well as of the other eye is necessary and especially all accommodative efforts of either eye, such as reading and writing, should be strictly forbidden for a long time, until all signs of irritation of the injury have disappeared. (5) Rest of the eye is greatly favored by the use of atropine to the injured one; (one drop of a one-grain solution, may be used every two hours), and by the use of dark blue glasses. (6) The rest should extend not only to the use of the eye, but the patient ought to remain quietly in bed in a moderately darkened room and ought to avoid all muscular efforts, which might possibly affect the eye, such as lifting heavy objects or stooping. (7) Shortly after an injury of this kind, mild saline cathartics, such as bitter waters or Rochelle salts, may be indicated. (8) Later if there is any exudation, the use of iodide of potassium or of small doses of hydrargyrum (see plastic cyclitis) may be of great service.

SYMPATHETIC OPHTHALMIA.

It had long remained a mystery how a disease of one eye could cause the same diseased condition in the other eye. The fact however, that if one eye is inflamed the other eye shows more or less pronounced signs of sympathy with the diseased eye, even if the trouble is only superficial and unimportant, as for in-of the chain, could only be caused by nerves which control the most important functions and the nutrition of the eye, and these are the ciliary nerves. There may be and there are other channels that are able to transmit a diseased condition of one part of the body to another, but there must be necessarily a direct communication between these parts, and the disease itself would naturally show itself along the course of this channel and affect the different parts in a similar manner to the part first affected. This is, however, not always the case in sympathetic ophthalmia.

It was supposed at one time that the disease might be transmitted through the coats of the blood-vessels, but this is hardly possible, nor can the lymphatics play a very important role in this respect. Then there is the optic nerve, which is undoubtedly in more direct connection with the other eye than any other portion of the eyeball by means of the inter-retinal fibres and the connection existing between the nerves of the two eyes at the optic chiasm. Along this channel affections of the retina and of the optic nerve are undoubtedly transmitted at times from one eye to the other; but it cannot possibly transmit a diseased condition that is not in direct connection with the nerve, or one that would leave it entirely intact and show itself in parts not at all connected with it. For instance how could the appearance of a disease of the iris be explained by an action of the optic nerve, or how could a diseased condition be transmitted from an eye whose optic nerve-fibres have become entirely atrophied, or as it sometimes occurs even after the thorough section of the optic nerve-fibres, after an enucleation for instance, if there was no other channel through which it could be conveyed. The medium of conduction is undoubtedly the ciliary nerves. The irritation is transmitted to the brain and from thence to the fellow eye. This explains the peculiar phenomena of such transmissions, that the disease is apt to appear exactly in the location corresponding to that which it occupies in the eye originally diseased. If we have for instance a portion of the ciliary body in its upper and outer section of the eye diseased and tender on pressure, this same tender condition of the upper and outer portion of the ciliary region of the fellow eye will be apt to be the first sign of a sympathetic inflammation of this eye. It is therefore probable that the diseases of that portion of the eye supplied by the ciliary nerves, especially those of the uveal tract, are transmitted through these nerves and those of the retina and the optic nerve are transmitted through the optic nerve.

Causes.—The causes that may lead to a sympathetic disease of the fellow eye are various, but they are generally such affections as implicate the ciliary nerves more or less directly, and especially diseases of the uveal tract, of the iris, the choroid and principally of the ciliary body are apt to lead to this formidable disease. The continued irritation due to the presence of a foreign substance in, or pressing on the ciliary body, is perhaps the most prolific source of sympathetic ophthalmia. Even if the foreign body lies in any other portion of the eyeball, it may sooner or later, by direct or indirect irritation of the ciliary nerves, lead to sympathetic troubles. This is one of the reasons why reclination of a cataract should be abandoned; the dislocated lens, acting as such a foreign body, may at any time lead to ciliary irritation by pressure on the iris, the ciliary body or the choroid, and thus cause the loss of the other eye. Next in order and almost as dangerous as the presence of a foreign body is a wound, and especially a lacerated wound in the ciliary region, and especially those in the sclera near the corneal junction. In this dangerous region which extends to about 4 mm. from the corneal junction, we find the largest number of nerves and blood-vessels; any injury of it is, therefore, liable to cause direct implication of the ciliary nerves. Beyond this line the danger is not so great. Ruptures of the sclera from blows are generally located five to six lines from the corneal junction, and are therefore not quite so dangerous in this respect. Corneal wounds are only dangerous if they cause complications of the iris, that may lead to irritation of the ciliary body. Operations in this region must be mentioned as another cause, such as cataract extractions and iridectomies, if the incision is made a little too far in the sclera. Iridodesis (see page 172) has been several times the cause of sympathetic ophthalmia on account of the constant traction of the iris. Diseases of the choroid, especially if complicated with degenerative changes, such as ossification, are also a source of danger. In fact sympathetic disease has been noticed after enucleations by the pressure or traction on the scar by an artificial eye, if the ciliary nerves were included in the cicatrix. Such a scar is generally sensitive to the touch and requires a resection of the stump or the use of the artificial eye has to be discontinued. If the optic nerve is included in such a cicatrix it should be carefully exposed and a portion of it removed. Swelling of an injured lens will sometimes, fortunately not often, lead to sympathetic troubles. A diseased condition of the optic nerve will sometimes extend through the chiasm to the other eye, which proves that sympathetic affections of the other eye may show themselves without the intravention of the uveal tract and the ciliary nerves. Also the retina may be the source of a sympathetic disease and even Herpes Zoster has led to it (Noyes).

Sympathetic affections of the fellow eye may show themselves in numerous ways. We have, however, to divide them into two groups, the one comprising those conditions in which no serious, permanent lesions have taken place, representing a kind of prodromatous state, which is called *sympathetic irritation.* The other group comprises those conditions in which we find the disastrous affection, that will eventually lead to the destruction of the eye, already established ; this has been called *sympathetic inflammation* or *sympathetic ophthalmia.*

Sympathetic irritation. Frequently during an inflammatory attack of one eye the fellow eye suffers more or less in sympathy, especially from photophobia ; this condition, however, disappears as soon as the acute symptoms of the original disease subside, or the cause of the irritation, such as a foreign body in the conjunctiva or cornea, is removed. This is not what we understand under the term sympathetic irritation. This name is reserved for those symptoms that affect the fellow eye after a more or less prolonged diseased state of the first eye, and that depend on an action set up through the agency of the ciliary nerves. It is probable that a true neuritis of the ciliary nerves is set up, travelling to the nerve centres and from thence to the other side of the body. The time required for this to come about is generally more than four weeks, but it may take considerably longer, in fact it may occur many years after the original injury to the eye, and as long as there is tenderness on pressure of the diseased eye, ciliary injection, photophobia, and other signs of irritation, there is danger to the other eye ; or it may happen that an injured eye has been perfectly quiet, not tender on pressure or showing any sign of irritation, when suddenly after some exciting cause, such as great accommodative efforts, exposures to cold and wet, or great changes of temperature, or by a lowering of the state of health of the patient or another perhaps only very slight injury to the affected eye, this becomes tender and painful again, and may now readily transmit the irritation to the other eye. In all these cases, however, the sight of the primarily affected eye had greatly deteriorated and in many cases the eye is totally blind. It is generally softer than in the normal condition and more or less tender on pressure, as I mentioned before, and shows a more or less pronounced ciliary injection, which becomes especially marked after the slightest irritation.

The first symptoms of sympathetic irritation are those connected with efforts of accommodation. We hear the patient complain about a weakness of the eye and of pain after using it for a short time, making it impossible for him to continue any fine work for any length of time. In order to relieve the accommodation the patient has to hold the object he is looking at, as far as possible from the eye, his near point recedes farther and farther away from the eye, and the range of accommodation becomes limited to a small space. Light irritates the eye considerably; it becomes watery and flushed if exposed to bright light, and there may be intense photophobia. Another peculiar feature is the sudden giving way of the accommodation; after looking at an object for a time, it becomes at once cloudy and misty, this lasts, however, only for a few seconds at a time. The patient complains also about neuralgic pains of the eye and the temples, especially after forced accommodative efforts; we hear at other times our patient complain about a sudden cloud coming before the sight, and his vision for the distance may have suffered, it may be reduced to one half its normal state; this is probably due to some retinal disturbance. There are also photopsies, the patient sees sparks and fire at this stage.

These symptoms vary in intensity and duration, lasting for a few seconds or even days, and are followed by a period of rest; but they are not accompanied by any lasting lesions of the eye, and the latter will return to its normal condition as soon as the cause of irritation is removed.

Sympathetic inflammation. This may have been preceded by vision may be greatly reduced in other cases; the pupil soon becomes contracted; the iris swells, it becomes muddy and spongy and frequently there is a distinct change in its color and more or less extensive posterior synechiæ will form, until the iris is firmly glued to the capsule of the lens. The ciliary body and the whole pupillary space is likewise covered with dense exudation, even more extensive and firmer than that of the first eye, and the vitreous humor becomes cloudy and more fluid. In more acute cases there is intense hyperæmia of the ciliary vessels extending to the iristissue in which often larger vessels can be distinctly seen; there is also great ciliary pain, and the exudation is very extensive and of a plastic kind. The tension of the eye becomes increased and the lens becomes opaque, cataractous. Later, on account of the contraction of the plastic material, phthisical changes and complete loss of sight may follow; or the eye may remain glaucomatous for a long time. The disease is as a rule very tedious and prone to relapses or exacerbations, until after many months or years the sight will be almost entirely destroyed; however it may occur, that the sight of the second eye is destroyed sooner than that of the primarily affected eye. The disease will manifest itself, generally in the way here described, as a serous iritis or as an irido-cyclitis or as an irido-choroiditis, but it may show itself in various other ways. The irritation of the diseased eye may also influence slight inflammatory conditions of the fellow eye, to such an extent that they do not only become serious but also very tedious; these will, however, improve at once if the cause of the irritation is removed by an enucleation of the primarily affected eye.

Treatment.—If there is any truth in the proverb that "one ounce of prevention is better than a pound of cure," it holds good in this case. If the disease has once been fairly established, it is next to impossible to cure it. Mild cases may make a comparatively good recovery, but they are exceptions. It is different, however, in regard to sympathetic irritation; this will be speedily and completely cured by the removal of the cause, and as sympathetic irritation is sometimes the beginning of a sympathetic inflammation, it makes it all the more advisable to remove the cause of it, by taking out the exciting eye, especially if this is blind or injured to such an extent, that vision with it is a matter of impossibility. It is different, however, if there is still some sight in the eye primarily affected, and if the other eye shows already signs of a sympathetic inflammation. Under these circumstances it will be best to defer the enucleation, because the first affected eye may become the better eye of the two, and because the enucleation of the one might benefit an inflammatory process of the second eye, but would not check it. If the first eye, however, is blind, it should be enucleated by all means, because this might modify the inflammatory process, and lead to a more favorable issue. In fact the enucleation of an eye, blind from traumatic irido-cyclitis, especially if there is a foreign body retained in it, and if it is irritable, should be insisted upon, especially if the patient cannot remain under constant observation, or if he is living at a place where he cannot readily get medical advice. Such eyes may remain perfectly quiet for a long time, and all at once become inflamed again, and transmit the irritation to the other eye within a few days, and this may become blind before anything can be done for it. If the inflammation has been once fairly established, it is next to impossible to arrest it, not even by an enucleation of the exciting eye. All operative interference with such a diseased eye is not advisable. An iridectomy if resorted to would do but little good, as the coloboma thus made would soon be filled up by a plastic exudation, but later, if all inflammatory symptoms subsided, it may do more good.

The treatment in the beginning of the disease should principally be—1. Complete rest of both eyes; no accommodative efforts of any kind should be allowed. 2. Avoidance of all irritation of the eye; the patient should be kept in a dark room and should be provided with a large shade, which must protect both eyes, if there is any vision left in the primarily diseased eye. 3. The use [redacted] possible, and this is most easily accomplished by giving the ient plenty of out-door exercise. Blue glasses should be used prevent the irritating effects of light. The most promising edy is perhaps mercury; it may be used in the form of the ate of mercury with morphine, which must be painted behind ear once or twice a day according to the age of the patient; he blue ointment, twenty grains a day, applied to the soles of feet, or the mercurial bath may be ordered, or the mercury be given internally, combined with the iodide of potassium tonics.

ENUCLEATION.

The object of the removal of an eye is generally to save the t of the other eye—to prevent an outbreak of sympathetic thalmia. Under these circumstances the enucleation is indi- d even before any signs of sympathetic trouble in the fellow have made their appearance, but it may have to be performed various other reasons; these are:

(1.) If an eye has been injured to such an extent that vision ns to be impossible for the future and if the injury implicates ciliary region to a great extent.

(2.) If the eye is blind and has been so for some time, and is painful and tender if touched in the ciliary region, indicating existence of a cyclitis.

(3.) If an eye has been blind for some time, and is subject to cks of inflammation.

(4.) If an eye is not quite blind, but if its vision is greatly re- ed; if it is tender in the ciliary region, and has given rise to pathetic irritation of the healthy fellow eye.

(5.) If an eye is not quite blind, but contains a foreign body ch cannot be extracted, and if the patient cannot be kept er observation.

(6.) If an eye is perfectly blind and gives no hope for future rovement and has set up a sympathetic inflammation in the ow eye.

(7.) It may be done for cosmetic effects, or to preserve the pe of the orbit, if the eye is blind and is the cause of an un- tly deformity, such as a total staphyloma.

(8.) It may become necessary and should be done promptly he diagnosis of an intra-ocular malignant growth has been de.

(9.) If an eye has become blind after glaucoma and remains y painful even after an iridectomy.

Enucleation is an operation comparatively free from danger, because the eyeball is taken out of the capsule of Tenon and the orbital tissue is not disturbed at all. This operation was introduced in 1857, by Prichard, for sympathetic ophthalmia. After the patient has been etherized, the eye speculum is introduced and the eyeball is fixed by means of the fixation forceps. The first step is the separation of the conjunctiva from the eyeball; we should try to save as much of the conjunctiva as possible, in order to retain a large conjunctival sac for the introduction of an artificial eye: it should therefore be cut as close as possible to the corneal junction. This may be done by means of a pair of blunt-pointed scissors, and if desirable the conjunctiva may be lifted up by means of a strabismus hook. After the conjunctiva has been thus separated, the capsule of Tenon is opened and the four recti muscles have to be divided as near as possible to their scleral insertion. By gentle pressure upon the speculum, the eyeball can now be easily dislocated from the orbit, which will put the optic nerve on the stretch and facilitate its division. The eyeball is now to be grasped by means of the fixation forceps and to be rotated outwards: a strong pair of blunt-pointed enucleation scissors, curved a little on the flat, are now to be introduced, *closed*, at the nasal side, between the capsule of Tenon and the eye and pushed to the posterior portion of the eyeball until the optic nerve is touched: the scissors are now to be opened as wide as possible and after the nerve has been gently grasped between the scissors, these must be pushed backwards as far as possible so as cut surface of the nerve, this appears healthy, the forceps may be removed, if there is any doubt about an extension of the growth into the nerve, this can be easily drawn forward and cut off as far back as necessary (Knapp).

After the removal of the eyeball there will be profuse bleeding from the ciliary, the retinal and the muscular arteries, which, however, can be easily controlled by the application of cold water, and is generally checked in a few minutes. After this a small surgical sponge is to be pressed on the lids, and is kept there for twenty-four hours by means of a tight pressure bandage; this prevents further hemorrhages and also the effusion of blood or the extravasation of serum into the orbital tissue as well as the annoying œdema of the lids, and facilitates the healing of the stump. After the sponge has been removed small pieces of iced cloths may be kept over the orbit for twenty-four to thirty-six hours until the conjunctival wound has healed.

The conjunctival sac should be kept clean during this time, by opening the lids and allowing a stream of cold water to run through the fissure. Later it will be necessary to keep the stump clean by washing it frequently during the day with clean water, and in case there should be any purulent discharge from it, with a mild solution of borax (ʒj to a pint of water). The stump after this operation is entirely covered with conjunctiva, and on moving the other eye, the action of the conjugate muscle can be distinctly seen in the stump. An artificial eye, which consists of a delicate shell of glass, is readily moved by this action of the muscle, and this accounts for the slight deformity, which may be hardly apparent. The artificial eye should not be inserted until the stump has thoroughly healed and hardened, which will be about two to four weeks after the operation.

The introduction of an artificial eye (*prothesis oculi*) is readily accomplished by drawing the lower lid of the eye downwards, and directing the patient to look upwards; the artificial eye is now pushed up under the upper lid as far as possible until the lower lid will close over it. In removing it great care should be taken not to let it drop on the floor, as it is liable to break; a large towel should therefore be spread over the patient's lap, the patient is again directed to look upward and the lower lid is drawn down with the left hand. The lower edge of the eye is now exposed to view and by raising it gently by means of the head of a pin or a pointed lead pencil, or by pushing the lower lid under the artificial eye, it will easily drop out of the eye.

An artificial eye can only be used as long as it is perfectly smooth; it will remain so, if well taken care of, for several years; as soon as it becomes rough, it will cause irritation of the conjunctiva and may even produce a slight sympathetic condition of the healthy eye. In the beginning the wearing of the eye may also irritate the conjunctiva somewhat, which may be relieved by a mild astringent remedy, such as a mild solution of sulphate of zinc, one grain to one ounce of water, or borax five grains to one ounce of camphor water. If later a conjunctival inflammation should set in, no matter from what cause, the eye should not be worn until all inflammatory symptoms have subsided, as this might give rise to ulcerations and later to cicatrization, that might make the use of an artificial eye impossible for the future. The artificial eye should be well matched with the other eye; its size will have to depend on the extent of the conjunctival sac; it may be necessary in the beginning to use a smaller eye, especially if it becomes necessary to wear one before all the swelling of the stump has subsided; but it may occur that cicatrizations take place after an artificial eye has been worn for some time and a smaller one will have to be used instead. The size depends, of course, only on the white part of the shell, the size of the cornea and the usual appearance of the eye remaining the same.

An artificial eye should be taken out every evening and cleansed thoroughly or kept in water during the night. These eyes are made to order or are imported.

Neurotomy or neurectomy of the optic and ciliary nerves have been recommended instead of enucleation, and may be resorted to when an enucleation is strongly objected to by the patient; but it should be distinctly understood that this operation does not offer the same amount of protection against sympathetic ophthalmia as an enucleation, because the divided nerves may unite again, or one or more of the small ciliary nerves may have escaped division; they are therefore able to transmit the irritation as well as if they had never been cut or the same as if all the nerves had remained intact. Neurotomy optico-ciliaris is a division of the optic and ciliary nerves; it is a comparatively new operation which has been in use only for a few years. It is done by opening the conjunctiva, after etherization of the patient, between the internal and superior rectus, say five or six mm. from the corneal junction; the eyeball is rotated outwards as far as possible, and after dissecting the surrounding tissues and opening the capsule of Tenon by means of the scissors, introduced through the conjunctival opening. The scissors are now pushed backwards, hugging the eyeball closely until the optic nerve is reached and divided. After this is done, the eyeball can be readily drawn forwards; the conjunctival wound is now to be held apart as far as possible by an assistant and after the posterior portion of the eyeball has been well exposed to view, all the ciliary nerves have to be carefully divided up to, but not including the insertion of the oblique muscles. After this has been done, and the bleeding ceased, the wound should be carefully cleansed and washed with a mild solution of boracic acid two grains to one drachm of water. The conjunctival opening is now to be closed tightly by one or two sutures, and a firm pressure bandage is to be applied for several hours. After this ice-cold compresses should be applied carefully, in order to keep the inflammation of the orbital tissue under control. There will be some exophthalmus and possibly some slight divergence of the eye for a short time after the operation.

Neurectomy, which offers more protection than a neurotomy, is performed in a similar manner, except that the internal rectus is divided during the first step of the operation and that the optic nerve is not divided until it has been brought well forward, and now a piece varying from three to four mm. is removed; the other nerves have also to be divided. On closing the wound the internal rectus has to be united again to its insertion. The after-treatment is the same as mentioned above. After the operation the cornea must be completely anæsthetic, except at the extreme periphery. If this is not the case, it is probable that one or more of the small ciliary nerves escaped division. The operation should in such a case be repeated and all the nerves be divided if possible. A return of the sensibility of the cornea, some time after the operation, even after an interval of many months, may occur. This is an indication that some of the nerves have become reunited, and this will likewise necessitate the repetition of the operation. This is by no means a rare occurrence, and considering the short space of time the operation has been practiced, a proportionately large number of failures have been recorded, (Knapp, Samelson, and others), and even the occurrence of sympathetic ophthalmia has been noticed some time after the operation of neurotomy. This shows that the operation is not as reliable as the enucleation of the affected blind eye. It should never be resorted to in cases of intra-ocular tumors, because in these cases the extension of the growth to the orbital tissues, through the walls of the eyeball, is the principal danger.

CHAPTER XII.

OPHTHALMOSCOPY AND TESTS OF VISION.

FOR the thorough knowledge of the diseases of the deeper tissues of the eye, which are described in the next section of this book, it becomes absolutely necessary to be familiar with the use of the ophthalmoscope. Before the discovery of this valuable instrument by Helmholtz in the year 1851, a disease of the optic nerve, of the retina, of the vitreous body and choroid were hardly ever recognized during lifetime, and were only known from *post-mortem* appearances. Now it is different, and the diseases of these parts are at present easier to diagnosticate, and their pathological changes are perhaps better understood than those of any other portion of the body. This is greatly due to the transparency of the media we have to look through; not only are the cornea, the aqueous humor, and the lens perfectly transparent, but also the vitreous body and the retina itself are in the normal condition so transparent that up to the pigmentary layer, separating the retina and the choroid, the slightest changes of the eye become at once apparent. Of the greatest help in these examinations is also the

The entrance of light to the posterior portion of the eye is through the pupil, and according to its size, the ophthalmoscopic examination of the eye is more or less easy. It is more difficult to observe what is going on in a room by looking through a keyhole, than it would be, if the door was wide open; if the door leading to the background or fundus of the eye is small and narrow, let us open it wide by means of the dilating properties of atropine, so that we can see the conditions of the retina or of the optic nerve with ease. The dilation of the pupil is of the greatest help in ophthalmoscopic examinations and should always be resorted to by beginners in the art of ophthalmoscopy. By bringing our eye as closely as possible to that of the patient we can see the fundus of a normally built eye, by means of the mirror of the ophthalmoscope alone; this is called therefore the direct examination of the eye. We do not only see the parts of the fundus in their exact location, but, as mentioned before, we see them also largely magnified, which will enable us to recognize readily all the changes that may take place in these parts. This is more difficult, however, if we have to look through a narrow pupil, or if the diameters of the eye are abnormal, so that the rays coming from the fundus of the eye, cannot be brought to a focus by our own eye. In such a case we must resort to the aid of a strong condensing lens, which will bring these rays to a focus in the air, two or three inches behind the lens, according to the number of the glass, forming here an ærial picture, which can be seen distinctly by the observer. This method is called the indirect method and the image that we see in such cases is naturally an inverted one. As the rays coming from the eye had to pass through a converging lens, the temporal portion of the fundus appears to be on the nasal side, the lower portion in the upper portion of the picture and *vice versa*.

The image is also condensed; the different parts of the fundus appear not so highly magnified, but on the other hand, we see a much larger portion of the interior of the eye. As the details of the fundus appear only magnified about three or four times, the area of the field seen, will be about three times as large as that seen by the direct method. Another advantage of this method is that any eye, normal, myopic, or hypermetropic, can be readily examined; at about eighteen inches distance, if the eye be normal, or by bringing our head nearer to the patient, say to about ten inches from his eye, if the eye to be examined is highly myopic, or removing it farther from the eye, say to twenty-four inches, if the eye be hypermetropic. This is therefore the most reliable method for a non-expert in the use of the ophthalmoscope.

In making an ophthalmoscopic examination it is necessary to have the steady, bright light of an argand burner, or a student's lamp; the patient should be placed in a dark room, a little in front and a little to one side of the light, and in the direct method, the examiner should sit at the patient's side. In order to examine the left eye of the patient, we have to use our left eye, and the left hand should hold the ophthalmoscope. Sitting at the left side of the patient and having the light on the same side, the examiner will be enabled to bring his eye within one inch of the patient's eye. On examining the right eye of the patient the light has to be on the right side and we have to sit at the patient's right side and use our right hand and right eye during the examination. The patient is directed to look at an object some distance off, which will relax his accommodation and place the eye in a state of rest. The observer's accommodation must likewise be relaxed; he must imagine that he is looking at an object far off. If he is not able to relax his accommodation sufficiently, he must use a weak concave glass, which, on account of its diverging properties, will enable him to see parallel rays near-by, a—24 or 1, 5 D is generally the glass best suited for this purpose. The most convenient plan to get a good view of the details of the fundus is to get the red reflex of the eye about eight inches away from the patient, and to approach slowly to the eye, keeping the illumination steadily in the centre of the pupil.

he observer, is now directed to look over the observer's left
lder, or at his left ear, if the left eye is to be examined ; or
ok in the direction of the observer's right ear, if the right eye
e patient is to be examined, without moving his head how-

The observer brings now the ophthalmoscope with his
hand to his right eye and illuminates the fundus, holding
ens with his thumb and forefinger in such a way, that the
passes through the centre at a right angle. By moving the
gently from one side to the other, or by moving our head
e from side to side, all the different parts of the fundus can
amined.

is always a good practice to examine the media of the eye,
gard to their transparency, at the beginning of an ophthal-
opic examination, because slight opacities might make per-
normal portions of the fundus appear indistinct or altered.
is done by looking at the fundus of the eye by means of the
r of the ophthalmoscope only from a distance of about twelve
s from the eye, holding the head at the same time a little
ays. The fundus appears red, and any opacity of the cor
ens, or vitreous is seen as a dark spot on a red background.

small central opacities may make it difficult to see the
s of the fundus. The differential diagnosis of these opaci-
as been described on page 177.

order to examine the fundus of an eye, either myopic or
metropic, by the direct method, the use of glasses, corres-
ing to the patient's myopia or hypermetropia, becomes
sary. These glasses are attached to the mirror of the oph-
oscope in such a way, that the glass corresponding to the
tion of the eye can easily be moved behind the aperture of
irror, so that the rays, coming from the fundus of the eye,
to pass through it and come to a focus on the retina of the
ver's eye. These improved ophthalmoscopes, with a num-
f glasses attached to them, are called refraction-ophthal-
opes, of which those devised by Loring, Knapp, and Noyes
e most perfect and useful instruments made in the world ;
made by Hunter, 1132 Broadway, enjoy the greatest repu-
.

e background or fundus of the eye, as seen by the oph-
oscope, appears at first as a uniformly red disc, but on closer
ination, the details of it become visible. The first thing to
t our attention is a round spot of the size of a silver five-
piece, if seen by the direct method, about 12 mm. in di-
r, which is lighter in color and has well defined outlines ;

this is the point of entrance of the optic nerve, and is called the optic disc or optic papilla. The lighter color of it is due to a less vascular condition of the nerve and to the absence of pigment at this portion of the eye; it is located at the nasal side of the fundus and can be easily found by looking for it in this direction. The outlines of a normal optic papilla are well defined and surrounded by a whitish ring, which is formed by a number of scleral fibres; this is called the scleral ring. At times accumulations of choroidal pigment cells are found to surround the optic disc, forming part of or an entire circle; this is called the choroidal ring. These are physiological conditions which are found in many eyes and must not be mistaken for pathological changes.

On examining the surface of the optic papilla a more or less central white portion of it is often present; this is due to a funnel-shaped depression of the centre, which is called a *physiological excavation.* It is of varying size, but it will never occupy the whole of the disc, and is very different from morbid conditions resulting in excavations of the optic papilla, and which cause a more or less uniform flat depression of the whole of the optic disc, see page 279. At the bottom of this pit a number of black dots may be seen; they are the perforations of the lamina cribrosa. By careful observation a number of vessels are seen on the surface of the optic papilla; some of them very small and more at the periphery of the disc; they are nutrient vessels; another set, larger than the first, are seen to emerge from the centre of the disc; these are the retinal vessels, the arteria centralis retinæ is a perfectly transparent structure; but in very dark eyes the retina may be distinguished as a delicate bluish film, especially near the optic disc, because it is here thicker than at other parts. Nor do we see anything of the choroid, except the red reflex of its vascular layer. This is what gives the background of the eye its red color if seen by the ophthalmoscope. In darker persons or in the negro, where the pigment layer is very marked, but little of the red reflex is seen; in fact in some negroes the background appears quite dark, and with this the light optic disc forms a striking contrast. The pigment appears in some eyes as fine little dots, especially in the centre of the fundus, in others as large, regular, black inter-vascular spaces at the periphery of the choroid. If the layer of the pigment is very thin, as for instance in highly myopic eyes, or if there is but little pigment, as in very blonde persons, or when it is entirely absent (albino), the larger choroidal blood-vessels can be distinctly seen. They differ from the retinal vessels by the fact—1, that they are much larger; 2, that they lie on a different plane; 3, that they do not radiate from the optic nerve to the periphery of the fundus; 4, that they are running in different directions, and 5, that they do not have a light streak running along the centre, as the retinal vessels have.

One of the most important portions of the eye, the macula lutea or yellow spot, is with difficulty examined by means of the ophthalmoscope, because it does not differ essentially from the rest of the fundus. It lies in the line of vision, directly behind the pupil; if the patient looks directly into the mirror of the ophthalmoscope we shall see the macula lutea, and if in the direct examination, the illumination is carefully moved from the optic disc to a point apparently twelve mm. from the optic papilla and a little lower than it, a portion of the retina is seen, which is free from larger blood-vessels, which only surround it in large curves, this is the macula lutea. This spot is of a darker red color than the rest of the fundus, and in dark persons it may appear almost black. In the centre of it we see sometimes a bright shining little spot or a very small white ring or crescent, corresponding to the fovea centralis; this is frequently seen in children, but in many eyes there is nothing of this kind to mark the location of the yellow spot.

Beginners do well to examine as many normal eyes as possible, because only after seeing the many variations of the normal fundus shall we be able to judge about the morbid conditions of an eye. It will be of the greatest help to bring the eyes under the influence of atropine before examining them; if it is not possible to make use of the atropia, the eyes of children with large pupils are also well adapted for ophthalmoscopic examinations and so are the eyes of rabbits. These differ from the human eye only by the frequent occurrence of opaque nerve fibres, which produce a change of the regular outline of the papilla.

The morbid changes of the different portions of the fundus in disease will be spoken of fully in the following chapters.

In order to diagnosticate impaired vision, which is so often the result of diseased conditions of the deeper portions of the eye, or to measure that remaining, comparison must be made between normal vision and that in the diseased eye.

Whenever we look at an object, we do not only see this object, but also a number of things in the immediate neighborhood of the line of vision, but we do not see them as distinctly as the object we have our eyes fixed upon. This plain, sharp vision of an object, we are looking at directly, is called central or direct vision; that of the surrounding objects, which we do not see as distinctly as the former, we call the peripheral or indirect vision. The first, direct vision, is that where the image of the object comes to a focus on the macula lutea of the retina; the latter, the indirect vision, is accomplished by the function of the parts of the retina surrounding the macula lutea: the nearer to the macula this portion lies, the more abundant are the nerve-elements of the retina and the more distinct will be the image of the object, whilst at the extreme periphery of the retina, the vision is very weak, and objects that are seen with these parts appear very dim and indistinct.

As the retina lines the posterior half of a globular body, and [redacted] the optic nerve, the retina or choroid, may result in great changes of the direct or of the indirect vision. Changes in the acuity of the direct vision of the eye are diagnosticated by comparison with the normal vision. For this purpose we have to resort to the use of test types devised by Snellen and others.

In order to see an object distinctly, the rays emanating from it must come to a focus on the macula lutea, and must not only form a true image of the object, but this image has also to be of a certain size in order to be recognizable; the smallest image that can be recognized is one that is seen under a visual angle of five minutes. A much smaller object, for instance a bright dot, may be seen under a much smaller angle, but the shape of an object cannot be seen under these circumstances. The visual angle is formed by two lines drawn from the extreme periphery of an object to the optical centre of the eye. The farther away an object is, the larger it must be in order to be seen under such an angle; if an object is near by it may be much smaller and is still seen distinctly. Snellen's test types are constructed in such a manner, that for testing for distant vision, plain letters are of such size that they can be seen under an angle of five minutes at a certain number of feet or metres, which is indicated by a number over the letters. Those marked xx or D. 6, should be recognized at a distance of twenty feet or six metres; those marked xl or D. 12, should, however, be recognized at a distance of 40 feet or 12 metres. If the sight or the vision of the patient is such that he reads the letters marked xx or D. 6, at twenty feet or 6 metres, his vision is normal, and we express this by the formula: $V=\frac{d}{D}$, in which d expresses the distance in which letters are seen and D the distance in which they ought to be seen; or by saying the vision is like $\frac{20}{xx}$ or $\frac{6}{6}$ or 1, or by $V=\frac{20}{xx}$. If, however, the patient can, at this distance of twenty feet or six metres, see only the letters marked forty or twelve m., which should be seen at a distance of forty feet or twelve metres, his vision must be imperfect, and the degree of the impairment of his vision is expressed in this case by the formula: Vision like, or $V=\frac{20}{xl}$ or $V=\frac{6}{12}$ or by $V=\frac{1}{2}$. It is better, however, not to reduce the fraction to smaller numbers, because the former indicates at once the manner in which the patient was examined, and at what distance we placed him from the test types.

For persons that cannot read, figures devised on the same principle have to be used. For testing also the vision near-by, smaller test types arranged on the same principle are used; those of Snellen and Jæger are the ones mostly resorted to.

If the vision of the patient is very much reduced, say for instance to $\frac{10}{200}$, that is, if he reads the largest type that should be read at a distance of two hundred feet, at ten feet only, or less, we may use our fingers held against a black background, for instance the dark coat of the examiner instead, and note the greatest distance he is able to count fingers in; if his vision is still more reduced, so that he cannot see fingers, we must see at what distance he is able to see the movement of our hand. If the vision is very much reduced, we must see whether he is able to differentiate between light and darkness, or at what distance he is able to see the light of a candle. In these examinations we should be careful to have the patient's back turned to the source of light, in order to avoid the dazzling effect of too strong a light. Daylight is best suited for these examinations. If the patient has to be examined by artificial light, we should see that the amount of light or the distance of the test types is so regulated, that we, if our vision is normal, can easily recognize the last line of the test types. If the patient can under these circumstances read the bottom line, his vision must be normal. The vision of each eye should be tested separately and carefully recorded.

If a patient sees double, this is called *diplopia* and is due to some disturbance of the harmony of the muscular apparatus, see page 58. We have binocular and monocular diplopia.

Testing for the *field of vision*. Great changes of the field of vision, such, for instance, that are the result of atrophy of the optic nerve, or of a chronic glaucoma, or are caused by a choroiditis, may be easily diagnosticated, if we measure the patient's field of vision by the extent in which he is able to see our hand or count fingers in the different directions of the field. In order to do this, we must place our patient with his back to the light, direct him, after closing one eye, to look at our nose; he must not move his eye away from it. Standing in front of the patient at a distance of about one and one-half or two feet, we must hold up our hand and move it in the different directions of the field, upward, downward, inward and outward, and find out whether he is able to count fingers in all directions of the field. In glaucoma, for instance, he will not be able to count fingers if they are at the nasal side of the field of vision: and in hemiopia, he will not be able to see them if they are moved across the median line to that half of the field of vision which lies to the opposite side of the paralyzed retina. If the patient's vision is greatly reduced, so that he finds it difficult or impossible to see fingers at this distance, a lighted candle should be used for this purpose. This is for instance the case if we want to test whether a cataract of our patient is complicated with diseases of the deeper parts of the eye.

A more accurate method is to measure the field of vision on a blackboard. The patient is directed to gaze steadily at a white mark in the centre of the blackboard, which should be a distance of twelve to sixteen inches away from his eye; this point is called the point of fixation. The other eye being covered, a piece of white chalk is now moved from the periphery to the centre, and the patient must be instructed to inform us as soon as he recognizes a white body; this spot is to be marked by a dot, and the chalk is moved from another direction toward the point of fixation, marking again the spot where it becomes visible to him. After repeating this in all directions and joining the marks by a line, the field of vision can be determined quite accurately. It is necessary that the patient's eye should be fixed at the central point during this examination; it should not be allowed to follow the chalk. The changes of the field of vision may be of great service to indicate changes taking place during the course of the disease; it is therefore of importance to preserve the exact extent of the field from time to time. This we are enabled to do by means of maps devised for this purpose (Noyes). The field of vision should be divided for this purpose into concentric circles at equal distances from each other which are intersected by a series of radiating lines corresponding to the degrees of a circle. For the accurate measurement of the field instruments, called *perimeters*, have been devised. (Foerster or Carmault).

The field of vision differs in different individuals, according to the size of the brow or nose, or according to the prominence of the eyeball; it is also larger if the pupil is dilated; but a myopic eye has a smaller field than a hypermetropic eye, because the retina is farther behind the pupil.

Irregularities of the field are generally the result of pathological changes of the interior of the eye, especially of the nerve-structure. If the field of vision is narrower than normal, we call this a contraction of the field; this may be concentric or irregular: a defect of any portion of it is called a *scotoma*, from "dark spot." If the patient perceives these himself as dark spots, they are called positive; if they become evident only by taking the field of vision, they are called negative scotomata. In order to test a patient for scotomata we have to carry a piece of chalk from the periphery of the field of vision to its centre in all directions. If the patient cannot see the chalk at any point of the field, this spot will correspond to a defect of the retina and is a scotoma; if this point is in the very centre of the field, it is called a *central scotoma* and indicates disease of the macula lutea. In the normal field there is always a blind spot, a little to the outer side of the centre, this is called the *blind spot;* it corresponds to the entrance of the optic nerve, to the optic disc. This portion of the eye is blind because it is devoid of nerve cells and of the pigmentary layer of the choroid. Each point of the field corresponds to an opposite portion of the retina; sometimes we have the entire half of the field wanting; if this is the nasal side, for instance, it must be due to a paralysis of the temporal half of the retina. This condition is called *hemiopia;* if the left or right side of each field is wanting, it is called *equilateral* or *homonymous hemiopia;* if the temporal half of each field is absent, it is called *temporal hemiopia;* in such a case the nasal half of each retina must be diseased or paralyzed.

Testing for the perception of colors is described on page —, (see Color-blindness). All colors are perceived more distinctly in the centre than at the periphery, and large pieces of color are easier to recognize than smaller ones, especially at the periphery of the field. Good illumination is likewise necessary for a correct distinction of colors; artificial light, gas, candle or lamp-light are insufficient; daylight or electric light are absolutely necessary, and a dark background, such as black velvet, is preferable (Donders).

Testing for changes of the intra-ocular tension, which is often met with in diseased conditions of the eye, we direct the patient to look downward, and placing two fingers on each eye, we can, by pressing each eye gently, easily tell the difference of the tension of the two eyeballs, if it is not alike. A little practice will teach us what the normal tension is. According to the degree of hardness we have either normal, increased or decreased tension. The tension of the eyeball is always slightly increased in old age; this is due to rigidity of the sclera. In diseased conditions of the eye the tension may vary considerably; if it is higher than normal we call it increased tension; this and the various degrees of increased tension are expressed by the following signs: t+1, t+2, t+3; if the eyeball is softer than normal, we express the decrease of tension by t—1, t—2, or t—3; this means, if the eyeball is a little softer than in the normal condition, we call it t—1; if it is very soft, for instance in phthisis bulbi, we express this by the sign t—3; if the tension is normal, this is expressed by: t n.

CHAPTER XIII.

THE CHOROID.

THE choroid forms the posterior portion of the uveal tract; it extends from the entrance of the optic nerve, where it is firmly attached to the sclera and retina, to the ora serrata; here it is continuous with the ciliary body and is also firmly attached to the retina; its outer surface is in contact with the sclera, its inner with the retina.

The structure of the choroid is similar to that of the iris or ciliary body. We have an outer layer, composed of delicate epithelial cells, the epithelial layer; this is in contact with the lamina fusca, which separates the choroid from the sclera, but which is considered by many as a part of the choroid. The lamina fusca is composed of a loose network of fibres, which contains many pigmented cells. The stroma of the choroid consists of a network of connective tissue and elastic fibres; they serve for the support of the large number of blood-vessels and nerves found in this tissue. In the stroma we find also a number of cells, some pigmented and some without pigment; they are scattered uniformly over the tissue of the choroid. The pigmented cells are irregular in shape and are more numerous than the non-pigmented ones. The pigment of these cells varies from a brown to a jet black color. To the inner side of the stroma is a perfectly transparent, structureless membrane, the membrana limitans, and on the inner side of this we find the uveal or pigmentary layer. This layer is considered by some to belong to the retina, but it is generally looked upon as a part of the choroid; it plays always an important rôle in inflammatory affections of the choroid and is but rarely affected in those of the retina. It is formed by a single layer of cells, but it is thicker in the region of the macula lutea. The cells are flat and hexagonal in shape, and are filled with a dark pigment. This pigment is much darker and more abundant in the negroes and colored nations, and Europeans with dark hair, such as the Latin races, than in blonde persons, and is almost absent in albinoes. These variations change the appearance of the fundus, if seen by the ophthalmoscope, considerably. The cells of this layer are kept together by means of a structureless cementing substance, which becomes much thicker and broader in old age; these cells secrete a red fluid, called the retinal purple. The external portion of the rods and cones of the retina are imbedded in this layer and connected with its cells by means of delicate processes; but if the retina is separated from the choroid; these cells adhere to the latter.

The blood-vessels of the choroid form a considerable and important portion of its tissue; they are derived from the short posterior ciliary arteries, which reach the choroid by piercing the sclera near the entrance of the optic nerve; they divide rapidly into capillaries and these form the inner or capillary layer, the membrana Ruyschiana. The outer vascular layer is formed by arteries and veins; the latter, greatly preponderating and large, unite near the equator of the eye and form the venæ vorticosæ, generally four in number. The veins pierce the sclera obliquely, midway between the optic nerve and the margin of the cornea, and running backwards, empty into the ophthalmic vein; they carry most of the venous blood from the eye. There is free anastomosis near the optic disc with the retinal vessels and at the ora serrata with the other ciliary vessels.

The nerves of the choroid are derived from the ciliary nerves; they form a dense network of fibres in the stroma, but their mode of termination is not known.

Examining the eye by means of the ophthalmoscope, we are not able to see much of the choroid: it is hidden from our eyes by the pigment layer, on the inner side of which lies the transparent retina and its many blood-vessels; of the choroid we get only the red reflex of the vascular layers. In very dark eyes, containing a large quantity of pigment, for instance in those of the negroes, we do not even get much of this red reflex of the fundus, but in persons with blue eyes and light hair the pigment is so scant, that the larger choroidal vessels can be distinctly seen through the pigmentary layer; this is also the case in such eyes, where on account of a diseased condition of the choroid, or on account of expansion of the eyeball and choroid, for instance in myopic eyes, the pigmentary layer has become thinner than usual.

The choroidal vessels, if they are visible, differ from the retinal vessels because: 1. They do not appear as distinct as the retinal vessels, which we see in every normal eye; the retinal vessels are superficial, because they are in the innermost layer of the retina and consequently not covered to any extent by it; but those of the choroid are seen through the entire thickness of the retina and the pigmentary layer, and lie on a plane posterior to the retina. 2. The retinal vessels run in an almost radiating direction from the optic papilla to the periphery; but the choroidal vessels are more irregular and run in different directions. 3. The choroidal vessels are much larger and appear as flat red bands, the retinal vessels are smaller and round. 4. The difference of choroidal arteries and veins is not as distinct as in the retinal vessels, and 5. the retinal vessels have a light streak in the centre, which the choroidal vessels do not have.

A peculiar arrangement of the normal choroid, which must not be looked upon as a diseased condition, is the striated appearance of the pigment at the peripheral part of the fundus; especially in old people, or if the choroid contains much pigment, we can see it as a dark mass, forming large oblong interspaces with lighter lines running through it: these lines correspond to the vessels which are not as dark as the rest of the choroid. In fair persons with less pigment, the blood-vessels may be darker than the inter-vascular spaces and appear as dark heavy striæ. If these inter-vascular spaces are visible nearer to the optic disc, they are not as oblong as they are at the periphery. Another normal condition is a dark stippling, which is especially seen in the region around the optic disc and the macula lutea. We have also spoken of accumulations of pigment in the shape of a crescent or part of a ring immediately around, or a short distance from the optic disc, the so-called choroidal ring; this must not be mistaken for a pathological condition. Even on the normal optic disc small accumulations of pigment may be seen occasionally that might be mistaken for small hemorrhages.

The changes of the pigment caused by disease are mostly due to extravasations into the choroid; this may be blood or serum, but it is generally a plastic material, which will crowd the pigment to the sides, forming a roundish patch of exudation, which in a recent state looks more or less transparent or bluish-white. In older cases, where the exudation has undergone degenerative changes, the spots look perfectly white, or yellowish-white and are surrounded by accumulations of pigment.

In older people the reflex of the fundus becomes less red, which is probably due to changes in the pigment and to the fact hat the cementing substance of the pigmentary layer becomes broader and thicker and more opaque. In the choroid of old eople we notice also, generally with but little impairment of ision, the appearance of peculiar shining little elevations, which ave the appearance of very small pearls, scattered over the surface of the choroid, especially at the periphery; they are vitreous bodies, attached to the elastic membrana limitans of the choroid; they have been called colloid excrescences or drusen.

CHOROIDITIS.

According to the nature of the inflammatory products, the diseases of the choroid are called serous, plastic and purulent choroiditis. The choroid, being a delicate membrane, becomes easily saturated with the products of the inflammatory process, and if these are copious also the surrounding tissues will be filled with the exudation. As the sclera on the one side is firm and resisting, the products will generally find their way to the retina and especially through the retina into the vitreous humor. This is generally associated with great changes of the pigmentary layer, especially if the inflammatory process resulted in the effusion of plastic material. The pigment may become entirely absorbed, or it may be increased at other places, or the pigment cells may be crowded together, leaving the infiltrated portion of the choroid without pigment.

Choroiditis is also accompanied by great disturbances of the vitreous humor; this will often undergo great changes during and after an inflammatory condition of the choroid. It will not only become very fluid, *synchisis* but its transparency is also greatly changed, it becomes cloudy; together with this we get an increase of the contents of the vitreous chamber, which will lead to changes of the tension of the eyeball. If there is an increase of the tension we express it by the sign: t +. Later in the course ot the disease, on account of contraction and absorption of the effused products, the tension may become again diminished, even below the normal state; this renders the eyeball soft to the touch, t —. There is always more or less impaired vision during and after an attack of choroiditis, not only of the central vision, but also the field of vision may be greatly changed, according to the location and extent of the disease. External signs, such as injection, lachrymation and local heat, are seldom met with in choroiditis.

A. *Serous choroiditis.* It is a disease that is seldom seen uncomplicated with other affections of the eye. The principal feature of the inflammatory process is the secretion of a thin serous fluid, which will generally find its way into the vitreous humor, and cause thus an increased tension of the eyeball, which is easily diagnosed by the touch. The vitreous humor becomes not only increased in quantity but it becomes also much more fluid, and more or less cloudy. The lens and iris are pushed towards the cornea, and the anterior chamber becomes very narrow. If the pressure is continued for any length of time, it will result in a paralytic condition of the iris, which may in very chronic cases lead to atrophy of the iris. The increase of pressure in the eye will however be felt also in the posterior half, and the optic nerve will eventually yield to the pressure; an excavation of the optic papilla, which is generally preceded by an atropic change of the nerve fibres, will be the ultimate result.

The process is at times very acute, accompanied by general febrile symptoms, pain and photophobia, but it may also be chronic and give hardly any trouble. The principal symptom of the disease is therefore an increase of tension, and together with this, there is more or less impairment of vision. This affects not only the direct vision, which may be generally reduced, but also the indirect vision, or the field of vision. This is due to the effect of the intra-ocular pressure on the retina and especially on the optic nerve fibres, and will be felt principally at the outer temporal side of the optic papilla, as we see it in glaucoma, because this is the weakest and most exposed portion of the optic disc. The patient will therefore not be able to see objects at the nasal side; and his field of vision will be contracted at the inner half. The pain as a rule is not severe, except in very acute cases, when the patient may not be able to sleep for weeks. Light is causing great pain and this and the photophobia forces the patient to remain in the dark, if possible. If the disease assumes such a violent character, it will lead soon to serious lesions of the optic nerve, but in the more chronic form, which is characterized by the fact that it may improve a little at times, only to return again, the ultimate result will be about as bad as in the former. The optic nerve will undergo fibrinous degeneration and will become atrophied, and vision will be eventually entirely lost. On account of the changes in the vitreous body, a posterior polar cataract may be developed, but an operation for such a cataract would not promise brilliant results and must be accompanied by great danger, on account of the fluidity of the vitreous body. If the intra-ocular pressure is great, it may also lead to complete anæsthesia of the cornea and to atrophy of the iris.

Ophthalmoscopic Appearances.—The cloudiness of the vitreous is the first thing seen, but is often not so dense as to prevent an examination of the fundus. This is however not greatly changed; there is hyperæmia of the choroid; the retina is saturated with the exudation and is slightly opaque, gray; the pigment changes are not marked as a rule; there are but few if any alterations of the pigment cells to be seen; the retinal vessels, especially the veins, are engorged and tortuous; the pulsation of the veins and in marked cases that of the arteries, can be seen as they run over the optic papilla. Later the optic disc becomes white and atrophied and more or less excavated.

But, as I said before, on account of changes in the iris or the vitreous body, the conditions of the fundus cannot often be studied.

Causes.—The disease is rarely idiopathic (syphilis); it occurs with serous iritis and is generally caused by extensive posterior synechiæ or occlusion of the pupil (Irido-choroiditis, Fig. xxiii). It is seen in highly myopic eyes, after a dislocation of the lens, and in traumatic cataract; or it is caused by staphylomatous bulgings and is often the beginning of glaucoma.

Treatment.—This must be directed to the cause of the disease; in serous iritis the formation of synechiæ must be prevented; all irritation of the choroid, by traction of anterior as well as posterior synechiæ, should be relieved by a broad iridectomy. Paracentesis of the cornea yields but temporary relief. Complete rest, atropine and blue glasses and especially the application of the artificial leech (Hœurteloup) to the temples once or twice a week, also the use of mineral waters, such as the Pullna or Karlsbad Sprudel, taken early in the morning is of great importance. Jaborandi or better the use of pilocarpine, hypodermically, in one quarter of a grain doses, once a day, will be of moscope these patches look white and are surrounded by a black zone (Fig. xxviii.) Later the fibrinous exudation is transformed into connective tissue; this change is accompanied by great shrinking and later atrophy of the patches. Or the exudation, after causing the destruction of the stroma of the choroid, becomes absorbed and a patch varying in size, according to the extent of the process, will remain where the sclera is visible. It is therefore perfectly white, glistening and a little depressed; but during the first stage of the disease the plaques appeared thickened and bluish-white. The patches may appear at times perfectly black on account of proliferation of the pigment cells, (Fig. xxviii.) These different changes are noticed frequently in highly myopic eyes; the patches are often very small, glistening white and appear as if they had been punched out of the choroid.

If the retina or the retinal vessels have not become implicated by the process, these vessels may be seen running over the atrophied patch; but if the retina also had become affected, the vessels are absent or hidden at this spot; in these cases the pigment of the epithelial layer, after the destruction of the cells, will be absorbed by the retinal tissue and the retina will appear as if it had been sprinkled with ink, or the pigment will be more or less diffused. The retina itself becomes firmly glued to the choroid and undergoes degenerative changes (destruction of rods and cones and pigmentary infiltration) *Chorio-retinitis.* This will be followed sooner or later by an implication of the nerve elements of the retina, extend to the optic nerve itself, and result in atrophic changes of the nerve.

The optic papilla, in the beginning hyperæmic, looks later perfectly white or bluish-white and the blood-vessels have become very thin and may eventually disappear entirely (Fig. xxviii). On account of the atrophic changes the choroidal vessels become more distinct and visible. Chorio-retinitis is frequently caused by syphilis and almost exclusively by acquired yphilis, but it may be congenital. I have seen it in children ho were born with it, the mother suffering with the same disease at the time of the child's birth. It affects the vision consid-ably, but does not end in complete blindness; the atrophy of e nerve is not apt to become complete. There is as a rule no ctensive exudation into the vitreous humor. Sometimes the tients complain about flashes and sparks of light, but there is ry little pain in the eye, except some vague specific or rheu-atic pains.

Choroiditis areolaris. According to the number and distribution of the diseased patches and according to their location, several varieties of this disease have been recognized. If the exudation is limited to one or a few patches, it is called *chorioiditis areolaris;* these diseased patches are apt to be large, and after the degenerative changes have taken place, they present a white appearance and are surrounded by accumulations of pigment cells, presenting the appearance of white spots with a black binding. These patches are generally found in a portion of the choroid near the posterior pole of the eye; their location can be made out by the corresponding defect of the field of vision and ~~is~~ can be easily seen by means of the ophthalmoscope.

Subjectively they appear to the patient as black spots, which follow the movement of the eye and are perfectly still when the eye is not moved. They are especially annoying in bright light or if the patient is looking at a white object, and are therefore very troublesome if he is reading or writing. The defect they produce in the field of vision is called a scotoma and, as it does not change its position, it is called a fixed scotoma. Its location can be found by letting the patient fix a central spot on the blackboard, and moving a piece of white chalk in the different directions of the field, at a point corresponding to the defect, the chalk is not seen. The size and location of the spot varies according to the seat of the disease. If the disease attacks a portion of the choroid near the macula lutea, it may be seen in the shape of one large patch, but it may have also the appearance of numerous white spots or spikes immediately around the macula; this is sometimes seen in myopic eyes.

Differential diagnosis: Muscae volitantes differ from the spots, complained of by the patient, by their number and the constant motion even if the eye is at rest, and vitreous opacities remain in motion for some time after the eye has been quiet; these will also change constantly in shape and location and are easily seen by means of the ophthalmoscope; those due to chorioiditis areolaris do not change at all.

If the patch of disease is located at the macula lutea, the retina is very apt to suffer early, because it is here very thin; it is called a *chorio-retinitis centralis* and will greatly affect the patient's vision, especially the central vision. He will perhaps only be able to count fingers at a short distance, but the indirect vision may be only slightly affected. Looking at the test types for instance, he may not be able to see the largest letter if he looks directly at it, but if he looks at a spot one or two feet from the letter, he will be able to see it distinctly with a peripheral portion of the retina. Having the patient look directly at you, he will tell you, that he does not see your nose, but that he can see your ears very distinctly. The defect of the field of vision is exactly central and is called a *central scotoma.* This disease is apt to be associated with small retinal hemorrhages in the region of the macula, or it may be a sequel to a choroidal hemorrhage and is apt to come on after exposure and imprudent use of the eyes, especially in myopia.

Sclerotico-choroiditis posterior, posterior staphyloma, is another form of choroiditis, which attacks frequently highly myopic eyes and which is caused by the traction of the choroid subsequent to the elongation of a myopic eyeball. The principal lesion in these cases is found around the optic papilla. It begins with atrophic changes of the choroid at the outer (temporal) side of the optic disc and if seen early with the ophthalmoscope, it appears as a small, white, well defined crescent, which becomes broader as the myopia and the length of the optic axis increases; in highly myopic eyes it may surround the entire optic disc and looks like a white patch, irregular in shape, over which the retinal vessels are seen to pass. The sclera becomes thin and is slightly bulging outwards at the posterior pole of the eye and many vitreous opacities may be present. There is also great loss of visual power. The process is extremely slow and is not accompanied by any outward sign of congestion or inflammation. It may lead to detachment of the retina or choroidal hemorrhages. The exciting cause of this affection are long continued efforts of convergence and accommodation, especially studying by insufficient light, and congestion of the choroid, caused by bending over during writing and reading.

Choroiditis disseminata. In this variety, which is the one most frequently met with, we have numerous patches of exudation scattered all over the choroid (Fig xxviii). The disease may develop gradually, but at times a large number of patches may be formed at once. They are located principally at the periphery of the choroid, and the vision of the patient may therefore only be slightly impaired; but the field of vision is generally considerably contracted. The vision is more affected if there are many vitreous opacities present, and if the disease continues to spread and attacks more central portions of the choroid. Eventually atrophic changes of the optic nerve will set in, unless the disease is promptly treated. At times a number of patches will coalesce and form one large spot; or the disease is superficial and attacks larger portions of the choroid, especially at the periphery. In the latter case the course of the disease is very slow and insidious and may have existed for many months before the patient became aware of it.

Causes. The disease is generally due to specific lesions, to acquired as well as to inherited syphilis, but it is generally one of the later manifestations of this disease; it is seldom seen earlier than two or three years after the initial lesion. It may also develop in myopic eyes and may be brought on by exposure and by a low state of health. It will sometimes follow in the wake of severe constitutional diseases. It is apt to attack both eyes, but not always to the same extent. The disease is also seen to develop after severe nervous shocks, especially if there was a predisposing cause, such as myopia or senile changes of the choroid.

Symptoms. There is no pain or objective inflammatory symptom accompanying the disease; the principal subjective symptom of the affection is loss of visual power. If the disease affects one eye, the changes in the choroid may be far advanced before the patient's attention is called to it, and this may be only accidental; but if the other eye becomes likewise affected, the disturbance of sight becomes at once manifest and medical aid is sought. But frequently the sight is early disturbed by vitreous opacities. The manifestations of these are manifold; they may cause the sensation as if a cloud or fog was settling over the sight, or they appear to the patient as extra-ocular objects, like flies or spider-webs floating before their eyes; the patients frequently try to catch these objects and to remove them. If the eye is kept perfectly still, the opacities of the vitreous will gradually settle to the bottom, and if they are small, they cause the sensation as if drops of water were falling down before the patients eye. Whenever the patient looks up, these flocculi, that had settled at the bottom of the eye, become stirred up; they cloud the vitreous humor and the patient can hardly see. If his vision is tested now, he may hardly be able to see the largest letter of the test types, his V may be $= \frac{20}{200}$ only, but after the opacities have settled again, his V may be $= \frac{20}{xx}$ or $= \frac{20}{xxx}$. Such patients may see perfectly well in bed, early in the morning, but as soon as they get up, their sight becomes blurred. There is generally impaired central vision, which may be due to lesions in the region of the macula or to cloudiness of the vitreous body; there is also more or less contraction of the field of vision, and frequently there are scotomata. As I mentioned before, there is seldom pain, but the patients complain either that everything appears red or green to them, or that they see flashes of light, or stars, or that dark specks are floating before their sight.

The most striking objective symptoms are the changes of the choroid, which have been spoken of, and the vitreous opacities: these latter may be so numerous that the changes of the fundus cannot be seen. The opacities are seen with the ophthalmoscope as dark floating strings and patches, or as fine little dots. The best way of examining the vitreous body for smaller opacities is by the use of a strong convex lens; one of 8 or 9 D should be moved behind the opening of the ophthalmoscopic mirror; with this the vitreous humor should be closely examined. The vitreous is changed; it is much thinner, *Synchisis*, and the plastic exudation is seen to float up and down with the slightest motion of the patient's eye. The opacities may remain permanent, but frequently they become re-absorbed, and if no relapses of the disease occur, the vitreous becomes perfectly clear and the changes of the choroid and retina become apparent. In many cases the exudation does not get into the vitreous humor at all; as a rule specific choroiditis is accompanied by numerous vitreous opacities. The iris is seldom implicated, but the formation of a cataract, especially of a posterior polar cataract, is sometimes seen in choroiditis of myopic eyes.

Treatment.—Plastic choroiditis is a very tedious disease and may, in spite of all treatment, result in great impairment of vision, especially if a central portion is affected. The process may come to a stand still or absorption of the effused material may take place, entirely without treatment; but this is very rare. The disease, however, can be controlled by medicines, which may prevent further progress, or relapses, that would be very apt to take place. The disease, being principally due to constitutional causes, requires the use of remedies suited to these conditions. In syphilis the mixed treatment has given most satisfaction; but it cannot be expected that atrophied patches can disappear, and it is therefore only in recent cases that we can expect to benefit our patient by treatment; in most cases we have to be satisfied to check the progress of the disease and keep the patient's sight as good, or better, as bad as it is. In recent cases the exudation may become absorbed, unless great changes in the structure of the choroid have taken place, and perfect vision be restored. For specific cases the following prescription is very good. ℞. Iodide of potassium ℥ss, Bin-iodide of mercury gr. i., tinct. gentian comp., syrup. simpl. aa ℥ii. Sig: A teaspoonful three times a day. In recent cases the mercurial salve, applied to the feet in forty grain doses, or less in weaker patients, every night, will do much good.

Of local applications, the use of the artificial leech (Hœurteloup) is the most important. It should be applied to the temporal region of the affected side and from one-half to one ounce of blood should be taken at a time. The leech may be repeated in two to five days, according to the strength of the patient. In very weak and anæmic patients, after one application of the leech, the dry cup may be used; for this purpose, a soft rubber cup is preferable; it is very powerful, but its action can be regulated very easily. After the use of the leech the patient must keep very quiet and remain in a dark room for nearly twenty-four hours; it is therefore advisable to apply it in the evening before retiring. The blood must be taken quickly in a few minutes, and it may be necessary to let the incision penetrate deep into the tissues. If the rather expensive artificial leech is not to be had, a rubber cup or a cylinder may be used to draw the blood after an incision has been made through the skin, three to five mm. deep. Leeches can not do much good, because they take the blood from the surface and the deeper structures are not affected by them. Absolute rest of both eyes is at the same time of great service. The patient should wear blue glasses or remain in a dark room. Also atropine may be used from time to time to ensure absolute rest of the accommodation. Steam baths are of great service, either a Turkish or Russian bath should be taken twice a week. They will be of great service towards clearing up the opacities of the vitreous. Hypodermic injections of strychnine in the temporal region have been recommended as improving the vision of the patient after the process has come to a standstill.

Good hygienic mode of living, avoidance of all stimulating beverages, such as liquors and coffee, and the use of a mild saline cathartic in the form of mineral waters is always advisable and beneficial.

C. *Purulent Choroiditis.*—This is one of the most dangerous diseases of the eye, because it is very apt to extend from the choroid to all the other tissues of the eye and result in nearly all cases in total destruction of vision; it is then called *Panophthalmitis* (Fig xxiv). Purulent choroiditis is most frequently due to traumatism; this may have been an operation undertaken for the restoration of vision, for obstructions of the pupillary space, for cataract and so on, especially if this was accompanied by a loss of a considerable quantity of the vitreous body. It is sometimes seen after minor operations, or after comparatively slight injuries, if there was a very fluid vitreous, or a condition of the eye predisposing it to choroidal irritation, such as myopia of high degree, or detachment of the retina, or prolapses of the iris; it may also be caused by a perforating wound, or especially by a penetrating foreign body. It occurs sometimes after cerebro-spinal meningitis or serious constitutional diseases, and it occurs also as a metastatic process after pyæmia, septicæmia or variola and during the puerperal state. If it is due to septicæmia it occurs generally within one week after the confinement; if due to pyæmia, it may occur much later.

The pathological changes are due to an extensive infiltration of pus-cells into the tissues of the choroid, resulting in a breaking down of this structure. The lamina vitrea is early perforated, allowing an extension of the process to all the other tissues of the eye. The vitreous humor is found early to be infiltrated, and also the ciliary body is early affected.

The pupil is moderately dilated, but cannot be fully dilated by atropia, because it is firmly glued to the surface of the lens. The reflex of the pupil is not black but dull, yellow; soon the iris participates; pus is found in the anterior chamber, and lastly the cornea or the sclera breaks down and the pus escapes.

Before this takes place the process may have extended from the sclera to the tunica vaginalis of the eyeball, exudation of serum, and even purulent infiltration of the subvaginal place may take place to such an extent, that the size of the eyeball appears very much increased and it becomes very prominent (*exophthalmus*). The return circulation of the blood is greatly interfered with, and this, with the extension of the hyperæmia to the conjunctival vessels results in marked chemosis, and in intense œdema of the lids, especially of the upper lid; in fact, the whole side of the face is more or less swollen.

Differential Diagnosis.—The appearance of the eye is, on account of these external manifestations, so much like that of an acute purulent ophthalmia, that the disease might be mistaken for it; but the loss of sight, the absence of a red reflex of the fundus of the eye, and later the presence of pus in the anterior chamber, and the breaking down of the cornea and the intense exophthalmus will render the diagnosis easy, especially as the vision of the patient is not affected in purulent ophthalmia. From an orbital cellulitis it is easily differentiated by the loss of sight and the changes of the interior of the eye, which in this affection are not present. From an orbital tumor, or a periostitis of the orbit, it differs by the direction of the eyeball, which in these affections is always pushed to one side, and by the acuteness of the symptoms of the panophthalmitis.

As I said before, the process results usually in a discharge of pus through the cornea or sclera, but at other times it comes to a standstill before perforation of the eyeball takes place, and absorption and contraction of the inflammatory products lead to an atrophic condition of the eye. But we meet also with cases where the process is chronic from the beginning. In these cases the infiltration extends slowly to the neighboring tissues; but it is frequently followed, during the later stages of the disease, by great changes in the choroid; *ossification of the choroid* is one of the sequelæ of this disease. This tissue is of a true bony structure, and beginning in the inner layers of the choroid (Knapp), it may invade the whole structure, from the entrance of the nerve to the ora serrata.

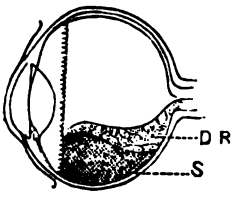
The pupil, during the early stages of this form of the disease, has a yellowish reflex, or plastic exudation may fill the pupillary space entirely, but in the chronic variety a perforation of the eyeball is rare. The result of this form is, however, as bad as in the more acute variety; the tissues have undergone such changes that sight is not possible; the eye becomes soft, quadrangular in shape (phthisical) and the contents of the eye form a dense connective tissue mass. The cornea becomes small and is usually opaque.

The *symptoms* of the disease are very marked, especially in the acute variety. There is intense pain, described by the patient as deeply seated in the orbit, and as if the eye was being torn from its socket; there is intense ciliary neuralgia, resembling hemicrania; there is also great local heat and very marked general febrile symptoms. The patient complains about intense photopsy; he sees bright flashes and rings of fire. The objective symptoms, such as the exophthalmus, yellow reflex of the pupil and other symptoms have been described before.

Treatment.—The principal object in the beginning of the disease must be to limit the inflammatory process as much as possible by the application of cold and leeches; but as soon as the presence of purulent matter can be detected in the vitreous humor, especially if it becomes visible in the pupillary space, the treatment has to be changed. The object should now be to hasten the process of suppuration and relieve the intense pain, which is done by the use of hot applications and large doses of morphine: a quarter of a grain of morphia may be given twice or three times a day, until the pain is lessened. Chloral hydrate or bromide of potassium give but little relief; applications of hot water or infusions of poppy-heads, however, give great relief to the patient; they hasten also the progress of the disease and should be applied frequently. During the intervals the use of a firm compress bandage gives great relief to the patient, but it seems to increase the pain at other times. As soon as perforation takes place, the patient is relieved of his pain, and if there is any sign of thinning of the cornea or sclera, the eye may be opened by an incision. The opening must be kept patent by probing it several times during the day. After a little while the opening will close and atrophy of the stump will follow. The greatest charity to the patient would be an enucleation of the eye as early as the disease is recognized, but not after pus has been formed; at this time it is not without danger, as the disease has extended to the meninges in some cases after an enucleation of the eye; this is probably due to the opening of the subvaginal space of the nerve-sheath, which will give an easy access of the purulent matter to the brain. The enucleation of the eye may be necessary even after perforation, if the disease had been caused by the presence of a foreign body, which was not removed with the discharge; such a condition might lead to sympathetic ophthalmia.

Sarcoma of the Choroid.—We have two varieties, the pigmentary and the non-pigmentary or small-celled sarcoma. Of these two the first variety is the more frequent; it develops from the inner layer of the choroid. The small-celled variety is seldom entirely without pigment. They take their origin from the outer layers of the choroid (Knapp). These tumors are made up of spindle-shaped and especially of round cells.

The pigmentary variety is composed of large cells; it contains a great amount of pigment, but only few blood-vessels. The non-pigmentary tumor is made up of small round cells and contains very little pigment; it is sometimes very vascular and contains large cavernous spaces. As these tumors develop, they are often accompanied by slight inflammatory symptoms, but they are generally so light that the patient does not pay any attention to them. Later, as they become larger, they lift up the retina, which becomes much disturbed, and results frequently in detachment of the retina; this may be very extensive at times, but toward the latter stages, when the tumor fills the interior of the eye to a considerable extent, the retina becomes absorbed. This may also be the case with the vitreous body, which, however, becomes



at times only compressed. In such cases the increase of the tumor produces great tension of the eyeball, which may become as hard as a stone; but frequently the vitreous becomes absorbed in the same proportion as the tumor increases, and the tension of the eyeball may be but slightly or not at all increased during the whole course of the disease, or may become even softer than in the normal condition.

If there is much increase of tension, the iris may be pushed forward, and become more or less paralyzed, and the cornea becomes anæsthetic. The conjunctival veins are generally large and tortuous; at other times the tumor presses on the iris itself, especially if it is implicating the ciliary body, and an irregular bulging of the iris into the anterior chamber takes place; the iris dilates only partly, and the pupil is oval or sometimes irregular in shape. Later the tumor fills the whole interior of the eyeball, and the lens may be pushed firmly against the cornea. If not interfered with now, the tumor is apt to break through the sclera and affects the orbital tissues. The points at which the tumor is especially apt to break through are at the posterior pole, where the sclera is very thin, or at the equator in the region of the venæ vorticosæ, or in the region of the sclero-corneal junction, or through the cornea itself. The growth of the tumor is very slow, and as it affects only one eye, the patient may not have noticed that anything is wrong with the eye, because it is not painful or inflamed; by this time the tumor may fill more than half of the interior of the eyeball, and the sight may now become greatly affected. If blackboard. As the tumor grows, the field of vision becomes tinually smaller, until at last the eye becomes entirely blind. Objective signs are few; there may be a large dull pupil, or re may be some irregularity of its contour. The tumor may only be seen pressing against the iris, but it may be seen, by ique illumination, through the pupillary space, as a pale white wth. But with the ophthalmoscope the diagnosis is comparaly easy. The tumor projects into the vitreous humor and aprs as a dark irregular bulging mass, because it does not allow light to penetrate it (See diagram.) It occupies frequently temporal or inferior portion of the choroid and is usually surnded by detached retina, from which it differs materially.

DIFFERENTIAL DIAGNOSIS.

SARCOMA.	DETACHED RETINA.
he tumor appears dark and solid.	1. The detached retina is in folds of a bluish color.
t does not vibrate when the eye is moved.	2. It is of a wavy, trembling appearance whenever the eye is moved.
t may be found in any portion of the eye.	3. It may develop in any portion of the retina, but will eventually gravitate to the bottom of the eyeball.
he retina overlying the tumor is usually atrophied and no retinal vessels pass over it.	4. The retinal vessels passing over it are numerous.
develops slowly.	5. It is apt to come on suddenly.
here is frequently increase of intraocular tension.	6. The eyeball is apt to be softer than normal.
appears in all kinds of eyes.	7. It generally occurs in myopic eyes.

The progress of the disease, if seen at longer intervals, will be of service. The tumor grows especially towards the eous body, and the field of vision becomes contracted at one . The detached retina spreads more and more at the perry, and the whole field of vision will become narrower.

From a glioma of the retina it differs, because it is more or less nented and appears dark if seen with the ophthalmoscope; generally found in old people. Glioma of the retina is a dis of childhood, which appears as a dense white swelling, over ch the retinal vessels pass freely.

Treatment.—The eye should be enucleated at once, as soon he diagnosis of sarcoma has been made. It will be found difficult to make uneducated persons understand the neity of this step and the importance of having it done early, cially if there is some vision left in the eye. But if the eye and the tumor is not removed, it is merely a question of time when it will cause the death of the patient. As long as the tumor is limited to the eyeball, its complete removal is easy, but after it has penetrated the eyeball and implicates the orbital tissues, a more extensive and dangerous operation, the removal of all the orbital tissues, including vessels and nerves, from the orbit, becomes necessary; sometimes the eyelids or the bones of the orbit may have to be removed, and even then the patient is not safe; the disease may show itself again at the same place or in some other part of the body. Therefore, to repeat, remove the eye containing the sarcomatous tumor at once.

Cysts of the choroid are very rare; they may contain cysticerci; the latter are almost unknown in this country.

Tuberculosis of the choroid accompanies acute miliary tubercles, but is never seen in common tuberculosis. The tubercles of the choroid appear, if seen by the ophthalmoscope, as minute round elevations, like white dots, or they are of a rosy color and ill-defined; they do not interfere with vision.

Of congenital anomalies of the choroid we have a defect of the whole thickness of the choroid (*coloboma of the choroid*), and an absence of pigment (*albinism*). A coloboma is an arrest of development of the choroid, resulting in a defect, that appears in an ophthalmoscopic examination as a well defined white band, running from the optic nerve to the ora serrata. It varies in breadth from three to five mm. and appears white, because the sclera is seen at this point. The retinal vessels can be seen pass-

Wounds and ruptures of the choroid.—Injuries of the choroid by a penetrating foreign body may become very dangerous; they may cause a panophthalmitis or a sympathetic ophthalmia. At the point of the injury the choroid will undergo degenerative changes, a white scar, surrounded by a black accumulation of pigment, will be the result. As an injury of this kind is generally in the peripheral portion of the choroid, the sight is not apt to suffer from it, unless it is accompanied by hemorrhages into the vitreous humor.

Ruptures of the choroid are caused by blows upon the eye with some blunt object. They are generally accompanied by some hemorrhage from the choroid, either into the structure of the choroid, or between the choroid and retina or into the vitreous body. The ruptures may not be visible until the blood has been absorbed. They are usually found in a portion of the choroid between the nerve and the macula lutea, and may resemble one or more delicate vertical lines with slightly darkened edges. In course of time they become, on account of the traction of the ciliary muscle on the choroid, slightly crescentic in shape and much broader. They are more or less parallel to the outline of he optic papilla, but they are frequently not very marked. At imes the rupture is seen as a long irregular line or lines with ne or more ramifications, that look like a rent made in very soft loth. Sometimes the borders of these lines show accumulations f pigment; frequently they show only atrophic changes. They use, as a rule, great impairment of vision.

Hemorrhages into the choroid are more or less round, and niformly red, showing no striations as the retinal hemorrhages e apt to do. They may be absorbed entirely, without much inry to the choroid, or they may leave an atrophied patch in hich frequently very bright crystals of cholesterine or hematoi- ne can be seen.

Treatment.—After an injury or a rupture of the choroid, the e should be kept perfectly quiet by the use of atropine and ue glasses. Cold in the beginning and later hot applications ay be used. The use of a small Hœurteloupe is in some cases beneficial results. The best plan is to keep the patient in bed a dark room, until the blood has become absorbed and the ndus has become clear, and until there is no more danger of rious complications.

CHAPTER XIV.

THE RETINA.

THE retina is the terminal expansion of the optic nerve; it is composed of nerve elements and stroma. The stroma consists of a network of fibres (Muller's fibres) principally radiating.[*] The retina begins at the optic papilla and extends to the ora serrata and lies between the choroid and vitreous humor; it is a delicate membrane, thicker at the optic papilla than at the periphery: it is very thin at the macula lutea and forms here a marked depression, which, if seen after the eye has been taken out, is of a yellow color, and is therefore called the macula lutea, or yellow spot. The central depression of the macula is called the fovea centralis; it is the seat of the most acute vision, and lies to the outer or temporal side of the optic disc. Clear and transparent in life, the retina becomes opaque and wrinkled after death. It is firmly attached to the choroid near the entrance of the optic nerve posteriorly and at the ora serrata in front; the rest of it is but loosely attached to the pigmentary layer, and effusions are apt to accumulate under the retina and detach it from the underlying choroid. It is not only sensitive to light, but also to pressure, which causes the sensation of flashes of light.

The retina has been divided into nine different layers, viz.:

1. *The columnar layer.*—This layer is the outermost portion of the retina; it is also called Jacob's membrane, and is composed of a large number of rods and a smaller number of cones, interspersed at regular intervals among the rods; they are closely arranged together like pallisades. The layer is thicker at the optic disc and thinner at the ora serrata; the outer portion of it dips into the pigment layer, which secretes a red fluid, called the visual purple; this fluid surrounds the rods and cones and is decomposed during the act of vision. The columnar layer, also called the perceptive layer, is connected with the optic nerve-fibres and the inner layers by delicate prolongations. The rods are for the quantitative, the cones for the qualitative perception of light; the latter entirely make up this layer at the macula, where the keenest perception is located. The rods are cylindrical bodies which have an inner, thicker and a thinner outer por-

n. The cones are bottle-shaped, and consist of an inner, coni- and an outer thinner, cylindrical part.

2. *The external limiting membrane.*—This is considered by ny as not a distinct membrane, but as a condensed portion of supporting tissue. It is perforated by many foramina.

3. *The external granular layer.*—It is made up of cells, ellip- d in shape, and forms a nucleated enlargement of the more ternal rod and cone layer.

4. *The outer molecular layer.*—It resembles fine granules or clei; this layer is very thin and is traversed by fine fibrillæ.

5. *The inner granular layer.*—It is composed of small round lls with large nuclei.

6. *The inner molecular layer.*—It contains a very fine granular bstance, which is intersected by fine nerve-fibres and connec- e tissue elements, and is of uniform thickness up to the ora rrata.

7. *The ganglionic layer.*—It is composed of large round or al ganglion cells with large nuclei and nucleoli. The cells are nnected with the optic nerve-fibres of the next layer, as well with the outer portions of the retina, by branching processes. his layer is very thin and is made up of one row of cells except the macula lutea, where it forms several layers of oval cells. ear the optic papilla the cells are more closely arranged than the periphery.

8. *The nerve-fibre layer.*—This is composed of the terminal res of the optic nerve, which are very numerous and radiate m the papilla, where they describe a sharp curve, and run in directions toward the ora serrata; they are perfectly trans- rent homogeneous fibres, consisting of the axis cylinder only, d are devoid of medullary sheaths. These filaments are not sitive to light; they merely transmit impressions from the er parts of the retina to the brain. This layer is of course ch thicker nearer the optic papilla than at the periphery. The es terminate in fine prolongations, which are connected with ganglion cells.

9. *The membrana limitans interna.*—It is a perfectly trans- ent membrane, which is made up of, but is entirely separate n, the retinal connective tissue; it lines the inner surface of retina.

The retina does not only vary in thickness at the macula lutea, it is also different in its anatomical arrangement. In the cen- of the macula we have a very small central depression, the ea centralis. The macula is so thin that the pigment of the layer underneath is seen through it. It is the seat of direct vision, and contains only nerve elements, no connective tissue or nerve fibres; the latter curve around the macula in large numbers; but it is composed especially of ganglion cells, which are here very numerous, and also the granular layer is much thicker at this point, nor are there any rods but many cones; they are closely packed together, and many fibres run from them to the retinal surface. The pigment layer underneath the macula is also greatly increased in thickness; in fact all the conditions for the most perfect vision are found here in this spot. The location of the macula is 2 to 2½ mm. to the outer side of the optic papilla, and is exactly in the centre of the retina, and corresponds to the visual axis of the eye; the large blood-vessels do not go to the macula, which has only a very fine set of capillaries, and the fovea centralis is also devoid of these. At the ora serrata the retina forms a serrated edge; it is here intimately connected to the choroid and the ciliary body, which begins here. The stroma of the retina, being devoid of nerve elements, is prolonged over and lies on the inner surface of the ciliary body, where it is known as the pars ciliaris retinæ.

The blood supply of the retina is derived from the ophthalmic artery. The central artery of the retina pierces, together with the corresponding vein, the optic nerve about 15 mm. before it reaches the eyeball; it runs to the centre of the nerve and reaches the eye through the central opening of the lamina cribrosa, which is called the porus opticus. After the interior of the eye is reached, the artery divides into two or three branches; these cross the optic papilla in an up and downward direction, and ramify and divide, forming bifurcations of acute angles, by which they are readily distinguished from choroidal vessels. They are distributed to all parts of the retina, except the macula lutea; they do not form a separate layer, but lie in the nerve-fibre layer, and run up to, but not beyond the ora serrata. The deeper structures of the retina have only capillaries. A set of lymphatic canals, which are connected with the optic nerve sheath, surround these vessels. They are the perivascular canals. The veins of the retina come together at more or less obtuse angles and form two or three trunks, which run over the optic papilla to the central opening in the lamina cribrosa; here they form the vena centralis retinæ; this does not open into the ophthalmic vein, but passes to the cavernous sinus. Anastomosis takes place between the ciliary arteries and the smaller retinal vessels only near the optic papilla.

of the macula lutea looks, as a rule, much darker, especially in highly pigmented eyes; no vessels reach this spot; they make large curves around it, and the fovea centralis appears, if seen by the direct method, as a small white point or as a white circle.

The whole retina is capable of receiving impressions, but the optic papilla is not, as it is devoid of ganglion cells, nor is there any pigmentary layer. The defect of the field of vision corresponding to the optic disc is called the blind spot of Marriot.

RETINITIS.

Inflammation of the retina, retinitis, originates usually in the stroma of the retina, and the nerve elements become secondarily affected. According to the cause and the nature of the inflammatory products, we have quite a variety of these affections.

Frequently the retina suffers from an extension of inflammatory processes of the optic nerve or the choroid, and at other times the retina becomes detached from the choroid by the effusion of blood, or serous fluid; or morbid conditions of the blood-vessels may exist, resulting in hyperæmia, in embolism, or in hemorrhages (*retinitis apoplectica*), or a disease of the retina may be characterized by proliferation of the pigment cells (*retinitis pigmentosa*). The retina may be hyperæsthetic (*nyctalopia*), or less sensative (*hemeralopia*). Its perception of the quality of light may be at fault (*color-blindness*), or the retina may be the seat of malignant growths (*glioma*).

signs of the disease. When seen by the ophthalmoscope, we may find hyperæmia, haziness or opacity of, or extravasations into the retina.

Hyperæmia of the retina.—This is not only one of the symptoms of retinitis, but it may also be due to the irritating effect of bright light and accommodative efforts, especially if they are due to a faulty refraction of the eye, such for instance as uncorrected hypermetropia and astigmatism.

A very marked vascularity of the retina is generally seen in young girls, as they approach the age of puberty, or in cases of dilatation of the heart and fulness of the general vascular system. It manifests itself by intolerance of light, which may be painful and cause even photophobia, and by an inability to use the eyes for any length of time, especially in bright gaslight. Examined at such a time with the ophthalmoscope, the condition is not difficult to recognize. There is a marked redness of the optic papilla, which might be taken sometimes for a neuritis, especially as the outline of the optic disc is not always well defined in cases of hypermetropia and astigmatism. The increase of the vascularity of the optic disc is not only due to an increase of the calibre of the nutrient vessels of the disc, but also because smaller branches, that are usually not seen, become now visible. There is hardly any change in the larger retinal arteries, but the veins are more tortuous and perhaps a little enlarged, and their pulsation is a little more distinct than usual.

It was formerly thought, that a hyperæmic condition of the cerebral circulation would manifest itself readily in the retina, and that the ophthalmoscope might be very valuable in the diagnosis of such cerebral affections; but if this is at all the case, it requires great experience to recognize these changes of the fundus, especially if the eye is examined by the direct method (page 230), because any error of refraction of the eye would increase the difficulty of the examination. But as the retinal vein empties generally directly into the cavernous sinus, and as the terminal retinal vessels do not anastomose with any other vessel, the retinal circulation is not easily affected, except by a disease of the optic nerve or by an increase of the fluid in the nerve-sheath; this results in marked changes of the optic disc and the retina, and will be described later.

Simple hyperæmia of the retina, if not caused by retinitis, may be relieved by the removal of the cause, by rest and avoidance of bright light, and by keeping the patient in a dark room, or by the use of dark glasses. Applications with the eye douche (page 80) and the use of an aromatic eye spirits, composed of essence of lavender one ounce, and essence of rosemary two ounces, will prove of great benefit to the patient.

Infiltration of the retina is a more important sign of retinitis; it may be diffuse or in patches of various sizes. The localized infiltration is generally found in the region of the macula or the optic papilla, and also the diffuse infiltration becomes here more apparent on account of the greater thickness of the retina; it causes a loss of the transparency of the retina, which is swollen, œdematous, and of a smoky appearance. The retinal vessels, or portions of the choroid that were visible before, are now veiled and obscured, or entirely hidden beneath the exudation. The outline of the optic disc is blurred and indistinct and the entire retina may look as if a grayish veil had been spread over the fundus. At the places where the infiltration is more intense, the retina has a decidedly bluish appearance. If the exudation is of a plastic nature, it is in larger or smaller patches of dense white appearance which surround the papilla or are near the macula lutea. The blood-vessels may be completely surrounded by the exudation, and degenerative changes of them are of frequent occurrence, which will lead to small hemorrhages in the neighborhood of these patches. The rest of the fundus shows seldom signs of disease; but the optic nerve will soon participate in the process, and may become atrophied, also the choroid may become slightly affected and sometimes there may be slight vitreous opacities present.

more comfortable in cloudy than in bright days, and better toward evening than in the middle of the day; but pain or ciliary injection is only rarely met with.

Retinitis is, as a rule, a disease of adult life, and is generally a slow chronic affection; its approach may be so insidious that it may exist for a long time before the patient becomes aware of it, because it is not accompanied by any unpleasant symptom except the loss of vision, which may not be noticed as long as the other eye remains good. The prognosis of these diseases depends upon the extent to which the nerve-elements of the retina have suffered; an atrophy of these parts must necessarily cause great and permanent impairment of vision, but if the stroma of the retina alone suffered, a complete recovery of vision may take place; this is especially the case in affections due to syphilis or irritation of bright lights. Marked limitations of the field of vision, extending gradually from the periphery to the centre, and great impairment of the central vision are bad symptoms.

Among the causes of retinitis we have irritation due to great efforts of accommodation, especially in bad light, or very bright lights, after the eye had been kept in complete darkness for a long time, or syphilis. It is also met with in some cases of Bright's disease, or is seen after retinal hemorrhages, and it may be the result of an injury. It is frequently associated with inflammatory changes of the optic nerve, and is then called a *neuro-retinitis.*

Retinitis specifica.—Syphilis is a frequent cause of retinitis. It is one of the later secondary manifestations, and occurs, as a rule, between the second and third year after the primary lesion. It is characterized by infiltration of large portions of the retina, and especially the macula lutea is apt to become the seat of the inflammatory process. On ophthalmoscopic examination the retina presents a diffuse gray appearance, which is especially marked along the course of the larger vessels; the outline of the optic disc is somewhat indistinct, and at the macula lutea small white dots and patches are frequently seen, which sometimes have a distinct radiating appearance. The disease is rarely marked by great hyperæmia; but the optic disc may show slight congestion, especially the finer, nutrient vessels of the nerve are very marked. The veins are tortuous, and as the retina is more or less swollen, the vessels may dip down into this tissue, so that portions of them cannot be seen; they may look as if they ended very abruptly, and some portions of them appear darker than the rest; there may also be patches of plastic exudation. The infiltration consists of small cells, and is followed later by a hyperplasia of the connective tissue elements, resulting in a thickening of the affected portion; the membrana limitans interna becomes ruptured, and on the inner side of it we may find marked connective tissue proliferation. The disease affects generally the inner layers of the retina first.

Retinitis is frequently associated with choroiditis (*chorio-retinitis*) or it follows these affections. There are sometimes very fine vitreous opacities present, which may give the fundus an indistinct appearance. The optical defect caused by the disease varies according to the seat of the infiltration. There is frequently a marked central scotoma, which is due to great changes in the region of the macula. Smaller defects of the field of vision may appear to the patient as dark spots of various shapes. There is also marked torpor of the retina; the patient sees much better in proportion in bright lights. On account of the irregularity of the nerve-elements of the retina, caused by the infiltration, objects may look bent or crooked, or they may appear smaller than usual.

The disease is, as has been said before, one of the later manifestations of acquired syphilis, but in rare instances it may also be due to congenital syphilis, coming on in the wake of a diffuse interstitial keratitis, and is also found in severe cases of iritis and in chronic irido-choroiditis. It is usually a very chronic process, lasting for many months, and may attack one or both eyes at a time. The acute retinitis maculæ luteæ, characterized by a central scotoma, may, however, disappear in a short time completely, if seen early and treated promptly. The chronic variety is apt to cause great impairment of vision.

Treatment.—The disease requires the most energetic mercurial treatment, which is to be continued for a long time, in order to prevent relapses. A hypodermic injection of $\frac{1}{24}$ of a grain of the bichloride of hydrargyrum is to be made into the temporal region once every day, or 40 to 60 grains of the mercurial ointment are to be rubbed into the soles of the feet every day, or the oleate of mercury may be painted behind the ears mornings and evenings, until the disease improves, or until the constitutional effects of the remedy become manifest. A milder preparation of mercury, for instance the protoiodide in doses of $\frac{1}{6}$ of a grain, may now be given twice and later only once a day for several months, or until all traces of the retinitis and other manifestations of syphilis, such as glandular enlargements, have disappeared. In very bad ases the mercurial vapor bath, or the use of the "Decoction of ittmann," which is made of sarsaparilla, senna leaves, and other erbs, and which contains also a mild preparation of mercury, will e of great service. The latter preparation is used very extenively in Germany.

Retinitis albuminurica or *nephritica*. This is one of the numerous complications of Bright's disease, but it occurs only in bout eight per cent. of all cases and is most frequently found with contracted kidney. It may, however, accompany affections that re only caused by pressure of the renal vein, for instance, in aluminuria of pregnant women. These cases offer the best progosis, and will often result in complete recovery, especially if the ffection developed during the later months of pregnancy. If it s due to a small granular kidney or other chronic renal diseases he prognosis is not so favorable; the sight may improve slowly fter the gradual absorption of the exudation, but the disease will enerally end with the patient's death. The affection of the retna is generally seen during the later stages of Bright's disease, ut at times the disturbance of vision may be one of the first ymptoms that induces the patient to seek medical advice, and he ophthalmoscope may reveal the existence of renal disease of which the other symptoms, due to the absence of anasarca, had een so obscure, that it had not been suspected. Retinitis albuminurica may affect one or both eyes, the latter is usually the case, lso in albuminuria of pregnancy; it rarely affects children, and s therefore seldom met with in renal disease due to scarletina.

The disease generally manifests itself as a neuro-retinitis, and he greatest changes of the fundus are usually found on and round the optic disc and in the region of the macula lutea: it esults therefore in great impairment of vision in most of these ases. The process may be divided into several stages: 1, that of xudation; 2, that of fatty degeneration, and 3, that of absorption.

In the first stage there is generally an infiltration of a serous luid into the retina, causing a bluish, hazy swelling of the central portion of it. The optic disc soon participates and marked hyperplasia of the stroma of the retina develops; the greatest thickening of the retina is found around the optic disc. The nerve-ibres of the retina as well as of the papilla undergo similar changes; the optic disc begins to swell and the nerve-fibres proect more or less into the vitreous body. The disease is seldom seen at this stage.

In the second stage we find that the exudative material has undergone fatty degeneration; there are numerous cells with many fat-granules found in these patches. The ophthalmoscopic appearance is now greatly changed and so characteristic of the disease, that if once seen, it will never be forgotten. (Fig. xxx.) Numerous raised, glistening white patches are seen in the macula or on and around the edge of the optic disc; they are due to sclerosis of the nerve-fibres and to fatty degeneration of the connective tissue. The optic papilla is likewise raised and its contour is almost hidden by the patches of exudation, which will frequently coalesce and form a regular wall around it, the peripheral portion of which is irregular and scattered. On account of the swelling of the disc, the retinal vessels have to describe large curves as they pass over the wall of exudation; many of them are inbedded in the mass, and the coats of vessels may become likewise affected, or the exudation may cause compression or rupture of the vessels. The veins especially are easily compressed, they become very large and tortuous and numerous small hemorrhages are frequently present; they are usually striated or quite irregular. The arteries are less apt to undergo changes. The macula lutea is covered with numerous white patches, that look as if they had been splashed in with a brush; they are generally much smaller than those seen near the optic disc, and might sometimes be overlooked, unless a careful inspection of this part of the fundus is made.

The third stage is that of contraction and absorption. The prominence of the patches becomes eventually less marked, and by the continued contraction great shrinking of the spots takes place. At other times the plastic material is gradually absorbed, and vision may be restored in exceptional cases; it is of more frequent occurrence, however, that the formation of cicatricial tissue will result in permanent destruction of that part of the retina; the changes may extend through all layers of the membrane. Tortuosity of the vessels is often constant, and remains of hemorrhages with cholesterine crystals may be seen for a long time. The disturbance of vision varies very much in these cases, but it is as a rule greatly impaired, although total blindness is of very rare occurrence.

Treatment.—This must be directed especially to the main cause of the disease. Pilocarpine and a hot vapor bath, also tonics, and especially the muriated tincture of iron in large doses, is very beneficial; it may be combined with sweet spirits of nitre. Blue glasses and complete rest of the eye is absolutely necessary; but the patient should not be kept in a dark room, as this might have a bad effect on his general health.

Retinitis leucocythæmica.—This is one of the rarer forms of retinitis, which affects generally both eyes, and in which the fundus, if seen by the ophthalmoscope, is very pale yellow. This is due to the peculiar condition of the blood, which contains only few red blood-corpuscles and a large number of white ones. There is also a diffuse haziness of the retina; this is sometimes covered with fine white dots (accumulations of white blood-corpuscles). The dots are surrounded by a dark red zone, which is supposed to be due to slight inter-retinal extravasations of blood. At times numerous small hemorrhages can be seen. The principal changes in the retina are due to hypertrophy of its stroma, and the blood-vessels, especially the veins, are somewhat dilated. Extravasations may also occur into the choroid and into the vitreous body. It is often seen in leucocythæmia.

Retinitis suppurativa.—It may appear as a separate disease after injuries or embolism, or after the entrance of foreign bodies, but most frequently it is part of a panophthalmitis. The infiltration, which in the primary disease is especially pronounced in the region of the optic disc, or surrounds the foreign body, is composed of round cells and affects the nerve-fibre layer principally, which appears swollen. The infiltration results in a breaking down of the retina, but the débris is prevented from getting into the vitreous by the internal limiting membrane; this may, however, eventually yield and the vitreous becomes invaded. Numerous small capillary hemorrhages are also seen, and complete blindness is generally the ultimate result.

Retinitis apoplectica or hemorrhagica (Fig. xxxi.) — Hemorrhages into the retina are of comparatively frequent occurrence; they may be the result of a retinitis, but they may also be found without inflammatory conditions of the retina and may even be the cause of a retinitis.

The disease is generally associated with heart lesions, hypertrophy of the left ventricle, or it is due to a sclerotic or fatty degenerative change of the coats of the blood-vessels, and is therefore, in most cases, found in old and fat persons, when it is apt to be very marked. Retinal hemorrhages may also be due to a thrombosis of the central vein of the retina, and are then seen only in one eye, or they may be the result of an injury, in which case the effusion is apt to be solitary and large and is more likely to become absorbed again rapidly. In certain cases of glaucoma, or in constitutional diseases, especially gout, and in disturbances of the menstruation, hemorrhages of the retina are sometimes met with. They may also be the result of pressure of inflammatory products on the retinal vessels and are constantly seen in retinitis albuminurica or in papillitis (page 289). In rarer cases they may be caused by multiple emboli of the smaller branches of the retinal arteries, and are also seen in pernicious anæmia.

The hemorrhages occur mostly only in one eye and are quite nnmerous; the different branches of a large vein are sometimes surrounded with a number of small hemorrhages, and resemble a bunch of grapes. Sometimes the hemorrhage is quite large, and the coagulum may occupy a large portion of the retina, but this variety is of rare occurrence; if such an effusion contracts, it may leave the upper portion of the patch colorless whilst the lower one is dark red. As a rule the idiopathic hemorrhages are found near the small terminal vessels, which terminate suddenly at the seat of the extravasation. At times the retinal arteries appear distended by the coagula in certain places and are perfectly colorless, resembling white threads, at other points (Fig. xxxi.) The location of most of the hemorrhages, especially of the arterial ones, is in the nerve-fibre layer or in the perivascular sheath of the blood-vessels. Such extravasations appear more or less linear and streaked, whilst those occurring in the deeper portions of the retina are round or irregular in shape. The rest of the retina is generally disturbed; there is more or less hyperæmia and œdema of this membrane with tortuosity of the veins and at times with great narrowing of the arteries.

As a rule the disease is apt to come on suddenly and is frequently due to some exciting cause of which great excitement, violent coughing, or sneezing, or great muscular exertions and straining at stool are perhaps the most frequent. The attack may be preceded by headaches, or come on suddenly like an apoplectic attack, or it may occur during sleep; the patient waking up in the morning, finds that he cannot see with one of his eyes. Most of the smaller hemorrhages of the retina may be slowly but entirely absorbed, and the vision, which is always greatly impaired in these cases, especially in centrally located extravasations, may be restored to a great extent; but frequently small coagula remain, and the retina will become partly atrophied. The prognosis of hemorrhages, associated with inflammatory conditions of the retina or optic nerve, is always grave and depends upon the course of these affections. The greatest danger in these conditions is the development of a secondary glaucoma. At times bright crystals of cholesterine and hematoidine mark the seat of an old hemorrhage.

Differential diagnosis; this may be difficult in regard to choroidal hemorrhages. It is comparatively easy if one of the retinal vessels can be seen to be connected with the extravasation, but retinal vessels may be seen running over a patch due to choroidal hemorrhage, and then the distinction between the two becomes very difficult. Frequently, however, the course of the retinal vessel can be followed distinctly over the patch, which is seen to be on lower level than the vessel. A choroidal hemorrhage appears as an irregular and indistinct patch, and is not so well defined as a retinal hemorrhage, which is dark red if venous, and bright red if arterial, and generally oblong or fusiform, or distinctly round. Choroidal hemorrhages are generally associated with choroiditis, changes of the pigmentary layer and with vitreous opacities, which are exceptions in retinal hemorrhages.

Treatment.—Complete rest and the moderate use of the artificial leech are the most important points in the treatment of retinitis hemorrhagica. Mild saline cathartics ought to be given in the majority of cases, and also the use of the iodide of potassium may be of great service; it ought to be given in moderate doses. As a rule the bloodclot will undergo fatty degeneration, and may become slowly absorbed and seems to be little influenced by treatment.

Retinitis pigmentosa (Fig. xxix.)—This is a disease characterized by marked changes of the pigmentary layer; it is often hereditary and may be present at the time of birth, but it generally develops in early childhood or at the age of puberty, seldom in advanced life. It runs in some families and seems to be due, in some cases, to blood-relationship of the parents, for instance if they are first cousins. It is a very chronic affection, lasting often twenty years or more; it affects both eyes generally to the same extent, and results in great impairment of vision.

The characteristic feature of the disease is a hyperplasia and a migration of the pigment of the pigmentary layer into the retinal tissue. This is preceded by a local serous infiltration of the retina, and the pigment cells either proliferate or the pigment itself becomes free and the retina becomes infiltrated with it. There is also hypertrophy of the stroma of the retina and changes in the blood-vessels; their perivascular sheath becomes infiltrated with pigment, and they decrease in size considerably. The nerve elements atrophy, and this may extend far up into the trunk of the optic nerve. The choroid is generally free from inflammation, but it may become partly united to the retina by the inflammatory products of the latter.

The ophthalmoscopic appearance of the disease is very marked (Fig. xxix.) The central portion of the fundus may appear perfectly normal in the beginning, but in the periphery of the retina numerous irregular black figures, which have a reticulated appearance, are seen; this has been likened to that of bone corpuscles. The black patches have irregular prolongations that connect with those of other patches, but the accumulations of the pigment are never as marked as they are in choroiditis, nor are there any atrophic patches, and the reticulated appearance is extremely delicate and quite indistinct in some parts, especially at the extreme periphery. The disease extends gradually from the periphery to the centre, and the belt surrounding the free retina is more marked in its centre. The blood-vessels become eventually thinner or disappear entirely and the optic papilla becomes very pale and atrophic, and also the lens is apt to suffer (*posterior polar cataract*).

The most prominent symptom of the disease is caused by a torpor of the retina, especially of the peripheral, diseased portion, which manifests itself by the inability of the patient to see unless there is abundant light; toward evening, as soon as the sun goes down, they become almost blind; they see poorly on dark gloomy days. This is called *hemeralopia* or " night-blindness." On account of the peripheral seat of the disease there is also great narrowing of the field of vision, even if the central vision remains perfect. The patients do not see or recognize their friends on the street, unless they approach them directly, and as their lateral vision is very poor, they are apt to come into collision with passers-by or get often in danger of being run over. Later, as the disease advances, the visual field becomes very narrow and also the central vision becomes greatly affected, so that the patients are only able to go out in bright, clear days. Large defects of the field of vision become apparent even in bright light, and the patient may become eventually entirely blind.

Hemeralopia or night-blindness is, however, not only due to retinitis pigmentosa, we may meet with it often without any pigmentary changes of the retina and it may be due to specific retinitis or to diffuse vitreous opacities. The treatment of retinitis pigmentosa is very unsatisfactory; it has not been possible to check the progress of the disease by any special plan of treatment.

Hyperæsthesia of the retina.—This is sometimes met with independent of inflammatory changes of the retina, especially in young hysterical women or in nervous hypochondriacal young men; or it may come on after close application at fine work, especially if the patient has been working on bright glistening objects, such as brass or other metals, or has been exposed at the same time to unusually bright light. Errors of refraction or insufficiency of the interni are frequently present in such cases and may be considered as predisposing causes. We have the trouble frequently associated with a want of power and great irritability of the ciliary muscle, and accommodative efforts will cause in such patients very severe ciliary pains, and there is generally some hyperæmia of the fundus to be seen. Slight conjunctival irritation, or rather irritability, may also often be noticed. In fact the most intimate connection of the irritability of the optic, the motor oculi and the fifth nerve in such cases have been pointed out by some authors (Beard, Hutchinson). There are no anatomcal or ophthalmoscopic changes of the retina, except at times a slight hyperæmic condition of it.

The symptoms are great sensitiveness to light and an inability to use the eyes for any length of time. The patients complain about a very annoying dazzling and even painful sensation if exposed to the light; there are also frequently small little specks complained of floating and dancing before the patient's eye (muscæ volitantes). In severer cases this is followed by lachrymation and blepharospasm and severe ciliary pain. There is also frequently a morbid persistency of the retinal impressions for a long time after the eye had been closed. The patients prefer to stay in a dark room; they may in bad cases be unable to go out or do any work at daytime, but they are able to use their eyes much better in the dark (*nyctalopia*).

The treatment of this affection requires great care; correction of the error of refraction and tonics are of the greatest importance; the phosphates of iron, quinine and strychnine are of great service, and in hysterical women the valerianate of zinc, which should be given in the shape of sugar-coated pills, or Blancard's pills of iodide of iron may be used. A cold shower, bath and the use of the eye-douche may also be resorted to, and the use of blue or smoke-colored glasses is necessary. In obstinate cases the use of atropia, continued for some time, and the use of prisms in weak interni will be of great service.

Another similar affection is called *snow-blindness*, and is caused by travelling in snowy regions where nothing but the white snow s seen for days or weeks. The eyes become under these circumstances so irritable, that it is impossible for the patient to open them. Together with this photophobia there is pain and marked conjunctival trouble, which in most cases is perhaps due to the mechanical irritation of drifting snow. The unavoidable fatigue of such travels and perhaps insufficient food may act as predisposing causes. The disease may become serious, as it may interfere considerably with the progress of a journey. Dark glasses will effectually prevent snow-blindness, and the Esquimaux use stenopæic spectacles of wood with a small central opening for this purpose.

Anæsthesia of the retina is exactly the reverse condition of hyperæsthesia. The patient can only see in bright light; if the amount of light becomes less, his vision is greatly reduced, so that fine work is impossible on dark days, and toward evening he may not be able to find his way home; he does not recognize his friends and is apt to run against trees or large objects, that are easily seen by other persons; he sees however perfectly well at daytime and may have a vision of $\frac{20}{xx}$: it is therefore called *hemeralopia or night-blindness*. It is caused by prolonged exposure to bright light, especially if the system suffered from want of proper nutrition, and is therefore often seen in Lent, after abstinence of meat, or among sailors that have been on a long voyage, especially in southern waters, where the nights as well as the days are very light: it is known by the sailors as moon-blindness, and is supposed to be due to sleeping with the moon shining into the face. It is also due to severe blows or falls on the head (*amotio retinæ*), and is perhaps caused by concussion of the nerve fibres of the retina; it is seen in severe neuralgia of the fifth nerve, after non-use of the eye, for instance in squint, and it may be due to old age. We have seen that it is also one of the symptoms of retinitis pigmentosa and some choroidal affections.

Treatment.—If the affection is due to bright lights, or concussion, absolute rest of the eye and complete darkness will relieve the trouble in a few days; but if it is due to non-use of the eye, systematic exercise of the eye may improve the vision considerably.

Detachment of the retina, *Ablatio retinæ.*—The connection of the choroid and retina is not intimate, and effusions are apt to take place between the two membranes, causing a lifting up of the retina, which presents now an elevation that projects into the vitreous body. The detachment may vary considerably in size; it may appear only as a faint bluish streak, or it may occupy a large portion of the retina and in complete detachment the entire retina is separated entirely from the choroid, except at the entrance of the optic nerve and at the ora serrata, where the two membranes are firmly united. The detachment may take place at any portion of the retina, but no matter where it originated, it will eventually gravitate to the lower portion of the retina; it is therefore at this point that a detachment of the retina is most frequently seen.

The ophthalmoscopic appearance of a detached retina varies according to the extent of the lesion. The red reflex of the choroid may be dimly seen in light, and not at all in marked cases. In the latter case, the detached portion has a gray or bluish-gray appearance, and as the membrane is seldom tense, it looks wrinkled or wavy, and especially if the eye is moved, the tremulous appearance of the detachment is very characteristic. It is generally semi-transparent, especially if the fluid underneath is seous, but it looks darker and is more solid if the separation of he retina was caused by a hemorrhage. Smaller detachments appear as grayish streaks and are seen especially along the course of the vessels. At times the detachment appears as a small, tense ac projecting abruptly from the surrounding healthy tissue; but as a rule the swelling is flat and more extensive, passing gradually over into the normal retina. If the detachment is complete, hat is, if the whole retina is separated from the choroid, no red eflex of the fundus can be obtained, and the optic disc, is surounded by a bluish swelling, which resembles the calix of the "morning-glory." The retinal vessels are seen to run over the detached retina as usual; they do not undergo any marked hanges, because they do not anastomose with the vessels of the horoid.

The disturbance of vision is generally the principal symqtom which calls the patient's attention to the condition of his eye, but generally, before the vision is greatly affected, prodromatous ymptoms may be observed. The most frequent of these are phosphenes (appearance of flashes of bright light, stars, etc.); the ensation as if balls were floating in front of the eye, and especially as if drops of water were constantly falling down before the patient's face. The central vision is generally affected, and if the detachment is marked, large parts of the field of vision may be entirely obscured, and as the lesion is usually seated in the lower portion of the retina, the optical defect is manifest in the upper part of the field of vision. Such patients complain about a heavy cloud obscuring the upper part of objects; they see the trunk of a tree, but they do not see its branches; they see the floor, but they do not see the ceiling of a room. As the detachment increases their field of vision becomes narrower. If the separation is slight everything appears to them crooked or bent, just as if we see it through the uneven edge of a window pane.

Causes.—Detachment of the retina may be produced by various causes, but it is generally preceded by marked changes of the vitreous body. The separation itself is caused by serous effusions, due to inflammatory processes, or it may be caused by extravasations of blood between the retina and choroid. Such a condition is greatly favored by a shrinking or diminution of the bulk of the vitreous humor; or it may be due to an elongation of the eyeball in myopia, or it occurs with choroidal changes of highly myopic eyes, when it is apt to be symmetrical. It is also due to irido-choroiditis or to staphylomatous degeneration of the eye. As a rule the tension of the eye is decreased; it feels soft to the touch. The prognosis of the affection is always grave; the detached portion may become attached again after an escape or absorption of the separating fluid, and the vision may improve again; but as a rule the detachment will increase, and the affection will result in great impairment of vision.

Differential diagnosis.—The affection resembles a tumor of the retina or of the choroid by its appearance and also by the defect of a portion of the field of vision, and by the fact that these tumors are covered with partly detached retina; but the slow growth of a tumor, the fact that a glioma is generally a disease of childhood and that a tumor of the choroid presents a dark solid appearance, if seen with the ophthalmoscope, will aid us in our diagnosis. Frequently there is also increased tension of the eye in an intra-ocular tumor; whilst the detachment of the retina is more or less sudden, the tension is apt to be more or less diminished and it occurs as a rule in myopic eyes. (See page 255.)

Treatment.—The object of the treatment is to cause the absorption of the fluid between the retina and choroid, or to remove it by making an opening into the separation for the escape of the fluid. The first object has been accomplished by the use of hypodermic injections of Pilocarpine or by the use of an infusion of Jaborandi. The first is to be used in doses of a quarter of a grain injected in the temporal region every day; the latter by using half a drachm of Jaborandi in the shape of an infusion morning and evening. Steam baths, especially the Turkish bath, have been used for the same purpose. The absorption of the fluid is also favored by the recumbent position of the patient and complete rest of the eye. This is accomplished by keeping the patient in bed in a dark room, using atropine and a compress bandage at the same time. This is to be kept up for two or three weeks. If the disease occurs in highly myopic eyes, in which case it is apt to be complicated with choroidal disease, it requires the application of an artificial leech, once or twice a week, and the administration of iodide of potassium, combined with a mild cathartic, such as the fluid extract of Senna. The second object, the escape of the detaching fluid, is attained by an operation.

The eyeball is to be rotated inwards, and a cataract needle is passed through the sclera, either directly under the detachment or into the vitreous and from here into the swelling.

Another plan is to pass a delicate piece of gold-wire through the sclera and through the detachment, fastening it together and leaving it in the eye. This is to act as a drainage tube, which causes a gradual disappearance of the fluid. But this method is not without danger; it has led to sympathetic inflammation of the fellow eye. After the disappearance of the fluid the retina returns to its normal position, and if the nerve-elements had not suffered during this time, the retina may resume its function and the patient may obtain good vision again. But as a rule the treatment of this affection is very unsatisfactory and even if the retina becomes partly attached again, relapses are almost sure to follow, and if the disease is due to degenerative changes of the vitreous body, the prognosis is very grave.

Embolism of the central artery of the retina.—This disease is of rare occurrence; it was first seen and described by Von Græfe, 1857, and is caused by an embolus lodging in the artery near the lamina cribrosa or in one of the main branches. It results in sudden blindness, without pain or irritation of the eye. It is generally associated with heart disease and is apt to come on after excitement or muscular efforts; running up stairs, splitting wood or lifting a heavy object may serve as an exciting cause. According to the seat of the embolus, the blindness may be complete or only in a portion of the field of vision. Collateral circulation may become established after a short time, but as most of the branches of the artery are terminal and anastomose only to a limited extent with the neighboring retinal vessels, it is seldom that the retina resumes its normal function. The ophthalmoscopic appearance changes according to the seat of the embolus; if the artery itself is obstructed, the optic papilla is blanched in appearance, the retinal vessels become very much reduced in size, and the arteries especially look like fine threads; the veins are more or less filled, but they are not congested and contain but little blood. The macula lutea appears blanched, and the rest of the retina appears bluish-white and somewhat opaque.

The fovea centralis, however, appears like a round hemorrhagic spot; this is due to the thinness of the retina at this point, which permits the choroid to be seen as a red reflex. Eventually atrophic changes of the retina and the optic nerve will set in. In doubtful cases the possibility of producing a pulsation of the artery by pressure will speak against the presence of an embolus.

Treatment.—This has been very unsatisfactory; it becomes necessary to avoid all irritation of the eye. The clot becomes generally organized and firmly lodged in the artery, which will result in permanent impairment of vision.

Tumors of the retina.—These are principally gliomata and sarcomata; the latter take their origin generally from the internal granular layer of the retina, and are of very rare occurrence. A *glioma* takes its origin from the connective tissue elements of the retina; it is a tumor of very slow growth, which may remain intra-ocular for one or two years. It is not accompanied by any inflammatory symptoms; nor does it give any discomfort to the patient, and as it happens only in young children, its growth may not be suspected until it has nearly filled the entire globe. The peculiar look of the child, due to the appearance of the whitish tumor behind the pupillary space, may be the first sign of this formidable disease, amaurotic cat eye. It occurs only in children, especially between the second and fifth year, but it may develop sooner or come on a little later and will sometimes affect both eyes. It appears, if seen by the ophthalmoscope, as a white or slightly pinkish, irregular tumor projecting into the vitreous; in the beginning it may appear as a bright spot of a white color, which is soon surrounded by detached retina; but this appearance is seldom seen, because the patients are too young to notice any defect of vision. It is usually covered with some portion of the retina and some of the retinal vessels can be seen to pass over the growth, but at other times the vessels are more or less enveloped by the tumor, and consequently not visible to the observer. Surrounding the tumor is more or less detached retina, which differs from the growth by the fact that it is not so solid, that it is bluish-gray and that it vibrates whenever the eye is moved. As the tumor develops, glaucomatous symptoms manifest themselves, or purulent choroiditis may complicate the case.

These tumors are composed of numerous round cells and contain great accumulations of nuclei and small granular inter-cellular substance; there are also spindle-shaped and branching cells the size of the red blood-corpuscle present, and they a dantly supplied with blood-vessels, which traverse these growths in all directions. A glioma results in impaired central vision and in defects of the field of vision in the beginning and later in complete blindness. The disease is one of the gravest affections we have to deal with, because even if the growth and the eye have been removed, it may recur sooner or later and cause the death of the patient. The tumor, if allowed to grow, will fill up the eyeball and press the lens and iris against the cornea and the anterior chamber becomes very narrow; later the tumor bursts through the eyeball either at the posterior pole, in the region of the optic nerve, or through the cornea. In the latter case an easily bleeding fungoid mass, which eventually will become very large, projects from the eyeball. This will give rise to frequent and extensive hemorrhages and thus reduce the strength of the patient; or if the optic nerve becomes affected the disease may extend from here to the orbital tissue and cause marked exophthalmus; or it may extend to the brain, and later be the cause of metastatic affection of other organs (liver and spleen).

Differential diagnosis.—On account of the bright yellowish appearance of the tumor it is easy to differentiate it from a detached retina. The fact that it occurs only in children will serve to distinguish it from a sarcomatous tumor of the choroid.

Treatment.—The only way to deal with this affection is to enucleate the eye, and this ought to be done as early as possible, because the tumor might penetrate the sclera and affect the orbital tissues, and in this case all the contents of the orbit would have to be removed, and the probability of a return of the growth would be much greater as if the tumor had been removed during its intra-ocular stage. But even in this condition a recurrence of the growth may happen, either in the orbit or in the brain and thus cause death. As the optic nerve is often early implicated, as much of it as possible should be removed when the eye is enucleated. The nerve may be grasped by long curved forceps before it is divided (see page 224), and if after the enucleation it is found that the optic nerve is affected, it should be removed as far back as possible. If the tumor is not removed, it will extend through the sclera to the surrounding tissues; but in very rare cases the growth of a glioma may be checked, and later atrophic changes of it and of the eyeball may result in phthisis bulbi.

Color-blindness or Daltonismus. — The *function of the retina* is to receive the impression of rays of light emanating from objects, and to recognize not only their shape but also their color.

The layer of rods and cones of the retina is called the perceptive layer and is supposed to be especially concerned in the act of vision. The rods are supposed to be for the quantitative and the cones for the qualitative perception of light. We know that the eyes of night-birds, like owls, that have no occasion to distinguish between colors, have no cones whatever; their retina, being made up of rods entirely, is best adapted for the quantitative perception of light. The macula lutea of our eyes, which is not only the seat of the most acute vision, but also of the most perfect perception of colors, is entirely made up of cones; also, in the neighborhood of the optic disc and the macula lutea, where the layer of rods and cones is especially thick, we have likewise a condition favorable for the perception of colors, more so than at the periphery of the retina, where the cones are few. It has been shown that the perception of colors diminishes toward the periphery in the same order as the colors of the spectrum are arranged; red is lost sooner than green, and this sooner than blue.

Color-blindness is a lack of faculty for the discrimination of colors and appears to be due to an imperfect development or impairment of certain nerve-elements of the retina, probably due to a want or deficiency of the cones. This optical defect is either congenital or acquired. If it is acquired it is generally due to diseased conditions of the optic nerve, and is always associated with marked impairment of vision, and in rare cases it may be one of the manifestations of hysteria, or may be due to severe illness or injuries of the head.

Congenital color-blindness varies considerably in regard to the extent of the deficient recognition of colors. There may be no perception for colors at all; this is complete color-blindness or *achromatic vision*. Partial color-blindness is of much more frequent occurrence. It is generally seen amongst men, where it amounts to four per cent.; but it is hardly known amongst women and seems to be of more frequent occurrence among the lower classes.

This condition was first described by Professor Dalton, of England, who was color-blind himself; he could not see the red color of the rose, or the green of the grass; everything appeared gray to him. Lately, on account of several railroad accidents, which were due to the inability of the employees to recognize green or red lights sufficiently, the attention of the authorities has been called to the danger of employing color-blind persons for such positions. Total color-blindness is very seldom met with; faulty perception of one or several colors is, however, quite frequent, and especially green and the different shades of green are often not recognized ; these are generally taken for shades of gray or light brown ; also red colors are often not distinguished as such. The perception of blue or yellow is defective only in very rare instances. The normal visual power of the patient is generally not affected in congenital color-blindness. This affection is often hereditary and may effect whole families, but little is known of its cause or pathology.

Of late the detection of color-blindness has become a matter of great importance and it should be thoroughly understood by every physician.

A number of more or less complicated methods have been devised for this purpose ; but the plainer and simpler the method, the better will generally be the result of the examination. The method recommended by Dr. Holmgreen, of Sweden, who was the first to study this question of color-blindness thoroughly, consists of spreading a large series of one hundred or one hundred and fifty samples of different colored worsted on a table, and letting the patient select from these all the different shades of a color, that appear to him like the color that is named. If he is color-blind, he will not be able to do this accurately ; he will confuse other colors with the one named. This test is therefore called *confusion test.* If he is uneducated, he may sometimes not know a color by its name and yet be able to recognize it perfectly well. It is therefore better and safer to take three larger skeins as tests, which should be of (1) green, (2) bright red and (3) rose or purple color. One of these test-skeins is now placed separately, two or three feet from the other samples, and the patient must be directed to select all skeins that look like or resemble the specimen, which the observer selected previously.

1. If the first, the green test skein is taken, and he brings any shade of red or gray to the test-specimen, he will tell you that they all look alike to him, whilst other shades of green may not be recognized at all. This is the best proof that he is color-blind for green.

2. If the second test-skein of bright red worsted is placed separately before the patient and he is directed to collect all skeins that look like this sample, he will select dark brown, or dark gray and perhaps dark green, together with dark red skeins, because they all look alike to him if he is color-blind for red.

3. As said before, these two are the colors that are most apt to be mistaken, and the greatest care should be exercised in testing for them, as they are usually used for signals, and the use of

the rose-colored or purple test-skein should be resorted to. These colors are mixtures of red and blue, and the red-blind will only perceive the blue of it and therefore select blue skeins, whilst the green-blind selects green samples to match this test-specimen.

Congenitally color-blind persons may acquire the faculty of recognizing colors from a more or less marked intensity of shade of the colors. Frequently they are not aware that there is anything wrong about their color-perception; they will be able to recognize a decided red or green, because they appear lighter or darker to them, especially if they are accustomed to recognize and differentiate between these colors; red appears to them darker, green lighter than normal. However, they are not able to detect the different shades of these colors from gray or brown. This fact explains why color-blind people may have been able to recognize signals, given with these colors, without making serious mistakes.

Acquired color-blindness, due to affections of the optic nerve, is entirely different; such patients make the greatest mistakes, because they have not been trained to know a color by its peculiar brightness or darkness; this color-blindness is readily discovered, but in congenital affections of this kind, the greatest care is necessary, and the patients should be given a large quantity of samples to select from, and should be directed to find all the different shades that appear to him like the test-skein.

In acquired color-blindness there is generally great impairment of the acuity of vision; the patients may be able to recognize colors in the centre of the visual field without difficulty, but at the periphery of the field they are generally not able to do this. They may, for example, be able to recognize green or red perfectly well if they look directly at it, but if the color is held to one side of the point of fixation, they may call it brown or gray, if it is a red, or white, if the test is a light green. In order to test a patient for this purpose, he must look directly at a given point, and must not follow the test-color, which is moved in the different portions of the field, with his eye. The perception of green is usually early impaired and red comes next in order. The central space in which green is recognized is also smaller than that of red. At times we meet with cases where the central perception of color is lost entirely, but remains unimpaired at the periphery; this is called a central color-scotoma, and is usually due to abuse of tobacco and liquor.

It is very important to have good light for these examinations, because some colors are exceedingly difficult to recognize in insufficient light; red is the first to become indistinct, and blue is the one which is generally recognized with the lowest illumination. Artificial light, on account of its yellow color, presents many difficulties in this respect, and should never be used for this purpose. The patients should only be examined in bright daylight or electric light; but never in the direct sunlight, nor by gas or lamplight. Nor must any colored object with a bright reflex be used for these examinations, for instance colored papers are not reliable.

Test-skeins of colored wool of different shades are readily obtained at any worsted store, and can be easily arranged by every physician. Very complete sets of all these tests have been arranged by Dr. Cutter, and are published by Wm. Wood & Co., New York.

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CHAPTER XV.

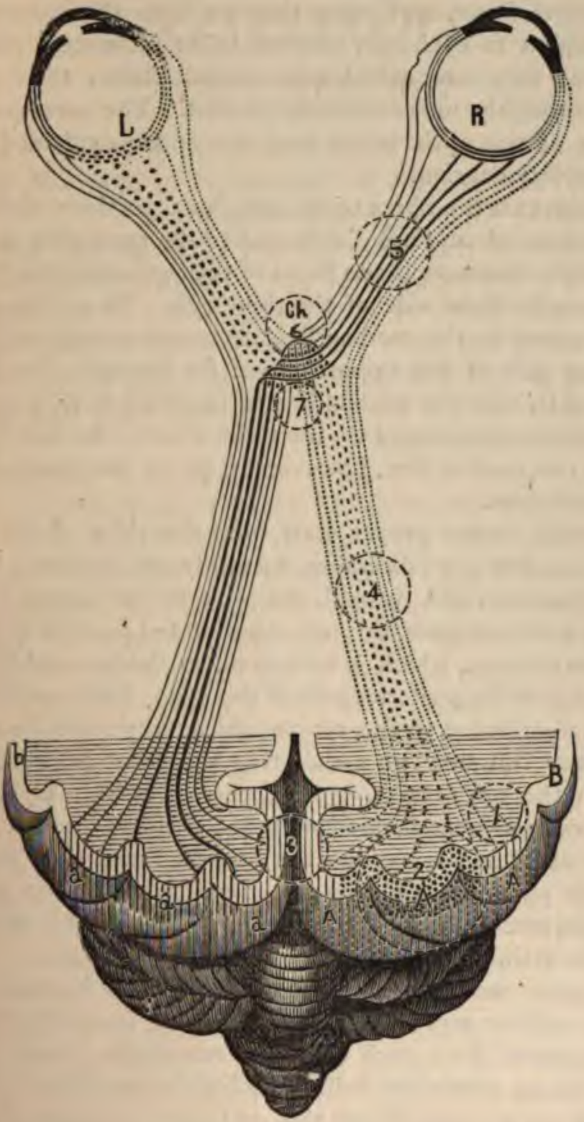
THE OPTIC NERVE.

THE second or optic nerve is the nerve of vision; it connects the retina, which receives the impressions of light with the cerebral centres, by which perception takes place.

The origin of this nerve is a very extensive one, and its distribution is to the retina of the eye. The two nerves, that of the right and that of the left side are connected at the optic commissure, which lies upon the olivary process of the sphenoid bone; they are called up to this point the optic tracts, whilst the name of optic nerve is given to the portion going from the optic commissure to the eyeball.

At the commissure a partial decussation of the optic tracts takes place, so that each nerve, after it leaves the chiasm, is composed of fibres of the left as well as of the right tract.

The principal seats of origin of the optic tracts are, (1) the optic thalami, and (2) the corpora quadrigemini; but each of the tracts has its ultimate or terminal fibres of origin in (3) the gray matter of the gyrus angularis of the occipital lobe of the brain. These fibres are arranged in such a manner that those of the left optic tract spread over and even a little beyond the left side of the gyrus, so that in the median line of the brain another partial decussation takes place; for we have some of the fibres of the left side, nearest to the median line, going over to the right tract and *vice versa* some of the right side going to the left tract (see diagram A), and any lesion of the posterior portion of the brain situated in the median line, must result in impairment of some of the fibres of both nerves and consequently affect both eyes. Some of the terminal fibres arise also (4) from the posterior columns of the spinal cord, and numerous fibres of the optic tracts are also derived from (5) the corpora geniculata, from (6) the crus cerebri, from (7) the tuber cinereum, (8) the lamina cinerea and from (9) the anterior perforated space. The optic tracts pass forwards beneath the thalami and curving around the crura cerebri, run toward the median line of the base of the skull, where they unite to form the optic chiasm or commissure. This is almost quadrangular in shape and rests on the olivary process of the sphenoid and is bounded at the sides by the anterior perforated space, nt by the lamina cinerea, and behind by the tuber cinereum. in the chiasm the decussation of the nerve-fibres takes place



ch a manner (see diagram) that a little more than half, about er cent. of the fibres of the inner side of the tracts pass over to pposite nerves and are now distributed to the corresponding of each eye, in such a manner that the fibres of the left tract go to the left side of each eye, and that after the decussation each nerve contains fibres derived from both tracts. There are some fibres that go to the posterior portion of the commissure, but do not decussate, nor are they continued forward; they are called inter-cerebral fibres, and some that go from the anterior edge of the chiasm to each eye, without being intimately related to the nerve; they are called inter-retinal fibres; their function is not thoroughly understood at present. The arrangement ot the fibres of the optic tracts and nerves are explained by the accompanying diagram.

It is seen that the fibres of the peripheral portions of the brain, b. B. run forwards and are distributed to the same side of the eye of that side—for example the fibres of the extreme right (1) of the head, go to the right side of the right eye. Those fibres whose origin is nearer to the median line decussate and go to the corresponding side of the opposite eye; for example the fibres of the right side, near the median line of the brain at (2) cross at the chiasm and are distributed to the right side of the left eye; the fibres of the median line, however, (3) go to the inner or nasal side of both eyes.

The optic nerves proper start from the sides of the chiasm and run in a divergent direction, outwards and forwards, through the optic foramen and through the orbit to the posterior portion of the eyeball and pass through a perforated part of the sclera, the lamina cribrosa, which is four mm., to the inner side of and one mm. below the posterior pole of the eye. The terminal nerve-fibres are distributed to the retina, which they reach by a gentle curve; they run now in a radiating direction from the optic papilla to the ora serrata, forming the nerve-fibre layer of the retina, which lies next to the membrana limitans interna. These fibres do not, however, go to the macula lutea, they only surround this portion; but they are connected with the ganglion cells of the macula, as well as with nerve cells of the other portion of the retina, by means of delicate prolongations.

The optic nerve, after it leaves the chiasm, becomes round and firm, and the nerve-fibres are arranged in fasciculi; these fasciculi, separated from each other by connective tissue and the vessels, take up about one-half of the bulk of the nerve. The individual fibres are exceedingly thin and each nerve contains more than four hundred thousand of them. The length of the optic nerve from the chiasm to the optic foramen is 10 mm. and from here to the eyeball about 28 mm. As the nerve leaves the chiasm, it receives a prolongation of the pia mater, the neurilemma, which surrounds the nerve closely and sends prolongations between the different bundles; it is finally continued through the lamina cribrosa and blends intimately with the inner layer of the sclera; this inner portion of the nerve-sheath is known as the pial-sheath. After leaving the optic foramen the nerve receives also a prolongation from the dura mater, which lines the optic foramen and at the orbital end of it divides into two layers; the outer one is continued along the bones of the orbit as the periosteum of the orbit; the other inner layer of it surrounds the optic nerve and forms the outer or dural-sheath of the optic nerve; as it approaches the eyeball, it splits into different layers, which blend with the sclera. To the inner side of the dural sheath and closely adherent to it, is a continuation of the cerebral arachnoid. The pial and dural sheaths are joined by loose connective tissue, and the space between them is called the inter-vaginal, sub-vaginal or sub-dural space, or frequently only Schwalbe's space, because Schwalbe was the first to describe it. This is considered as a lymph space and opens directly into the cranial cavity.

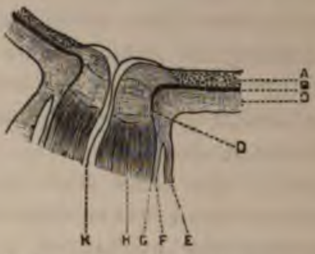
The entrance of the optic nerve into the eyeball is not through a large opening, but through a number of small apertures in the sclera; this is therefore called here the *lamina cribrosa*.

It is formed by strong scleral tissue, which is blended with the tendon-like processes from the neurilemma and forms little canals which communicate with the sub-vaginal space, and an increase of the fluid contents of this space is supposed to cause a dilatation of the little canals and may lead to compression of the nerve-fibres, of the connective tissue elements and of the blood-vessels of the nerve.

Before the nerve-fibres pass through the lamina cribrosa, they loose their medullary sheath; the nerve becomes a little thinner and after reaching the inner side of the eyeball, the fibres form a gentle curve in order to reach the retina and become slightly elevated above the inner surface; thus the inner side of the lamina cribrosa, which itself is much thinner than the sclera, becomes quite prominent on account of the nerve fibres. (See diagram.)

In this way the optic papilla or optic disc is formed; this is of a circular shape, about 1½ mm. in diameter, and has well defined outlines. If seen by the ophthalmoscope it presents a whitish or delicate pink appearance and on its surface a number of vessels may be seen; these are the retinal vessels passing over the nerve-fibres, and the nutrient vessels which run through the tissue of the papilla.

The retinal vessels, which are seen on the disc, are the artery and the corresponding vein; the central artery of the retina enters the substance of the optic nerve about 15 to 20 mm. behind the eyeball and runs forwards in the centre of the nerve, enclosed in a sheath of its own; it passes through a central opening of the lamina cribrosa, the porus opticus, and divides generally into two branches, one going to the upper and one to the lower portion of the retina; the central retinal vein accompanies the artery and leaves the optic nerve a little nearer to the eye than the artery and empties into the cavernous sinus.



A, Retina. B, Choroid. C, Sclera. D, Lamina cribrosa. E, Dural portion of nerve sheath. F, Sub-vaginal space. G, Pial sheath. H, Optic nerve. K, Central artery of retina.

The nutrient vessels of the nerve are derived from the anterior cerebral and the central retinal artery. The outer sheath of the nerve derives its blood supply from the ciliary and muscular arteries. Anastomosis takes place between these vessels, and the central vein of the retina anastomoses with the ophthalmic and facial veins. The lymphatics are very numerous in the sheath and nerve; they are connected with the sub-vaginal space and the lymphatics of the posterior portion of the eye.

A thorough knowledge of the anatomy of the optic nerve is necessary in order to understand the important rôle it plays in many cerebral affections and the changes it undergoes in disease. We shall have to consider in this chapter: 1. Hyperæmia of the optic disc. 2. Neuritis ascendens. 3. Neuritis descendens. 4. Atrophy. 5. Amblyopia. 6. Tumors of the nerve.

1. *Hyperæmia of the optic papilla.*—This may exist together with hyperæmia of other parts of the fundus of the eye, but it is seldom an indication of cerebral hyperæmia or congestion. It is seen in persons whose whole vascular system is engorged (see hyperæmia of the retina), and also in some forms of inflammation of the retina and choroid, and in neuritis or papillitis. The optic disc looks very red under these circumstances, so that its color is

almost the same as that of the rest of the fundus. This is due to an increase of the vascularity of the disc; the larger nutrient vessels become more distinct, and smaller vessels, that were not visible before this engorged state, are now quite prominent. The retinal vess ls are but slightly affected; the veins are, as a rule, a little thicker and more tortuous, but the arteries are not changed. In many healthy eyes, and especially in hypermetropia and astigmatism, the disc appears very red.

Neuritis nervi optici (Figs. xxxv. and xxxvi.). — Inflammatory affections of the optic nerve manifest themselves in different ways, according to the cause of the disease; but we have to distinguish especially two varieties of this affection, viz.: a neuritis ascendens where the process begins at the ocular portion of the nerve, and a neuritis descendens where the disease begins higher up in the nerve.

2. *Neuritis ascendens.*—In this disease the intra-ocular portion of the nerve, especially the papilla optica, undergoes great changes, and presents an appearance very different from that of the normal optic disc. We have seen that the sub-vaginal space of Schwalbe, which surrounds the optic nerve, is continuous through the optic foramen, with the arachnoid spaces of the brain. Any increase in the contents of the cranial cavity, which may be caused by inflammatory products, for instance by those of a meningitis, or which may be due to the growth of a cerebral tumor, will result in an increase of the fluid contents of the sub-vaginal space, and may cause a dropsical enlargement of it. As this space surrounds the optic nerve, this is apt to become compressed by the increased fluid or other inflammatory products accumulated within the sheath, especially at its inner point of entrance into the eye at the lamina cribrosa, where the hard resisting sclera prevents a distention in an outward direction; the nerve becomes slightly strangulated by the fluid. This results in a retardation of the venous circulation; the retinal veins become congested and appear large and tortuous, and slight œdema of the optic disc will result as a consequence of this. The œdema will gradually increase the longer the obstruction lasts, and the nerve and the connective tissue elements of the papilla become saturated with the serous infiltration; it swells considerably, and presents at this stage, if seen with the ophthalmoscope, the appearance of a *swollen disc.* The papilla looks now red and its outline is indistinct, it looks " hazy " and is raised considerably. The retinal vessels have to make a large curve in order to reach the retina and the veins have by this time become

very large and tortuous. The nutrition of the connective tissue elements is interfered with on account of the strangulation, and it will become likewise inflamed. Hyperplasia of it will result, which leads to great prominence of the optic papilla; this will project over the surrounding retina and the outline of the papilla that was at first indistinct on account of the œdema, is now entirely hidden by the swollen nerve and connective tissue elements. The surrounding retina becomes likewise affected and has a striated, feathery appearance, which is due to the radiating direction of the nerve fibres and the inflammatory products surrounding them. The coats of the blood-vessels suffer also from the inflammatory process and especially the veins become compressed by the inflammatory products, to such an extent that they are not only intensely congested all over the retina, but are often ruptured near the papilla, and small hemorrhages surround the optic disc or are seen on the papilla itself. It is seen that these symptoms thus far affect only the intra-ocular portion of the nerve, and especially the papilla, and it has therefore been called *papillitis*, or, as it is principally due to a strangulation of the nerve, it is also known as the *choked disc.*

If at this time the cause is removed, all these symptoms will gradually disappear; the exudation is slowly absorbed and the eye returns to its normal condition. But if the inflammatory process advances, the nerve-fibres themselves undergo great changes, making a perfect recovery of vision impossible. This may be partly due to the contraction of the inflammatory products, which causes at the same time compression of the central artery of the retina, thus diminishing the amount of blood entering the eye. The congestion of the papilla will diminish, and the disc looks opaque, hazy and grayish in color, but it is still considerably swollen; this is called a *woolly disc.* Still later the nerve-fibres become atrophied or undergo fatty degeneration, and the disc becomes gradually very pale, its outline more distinct, and it forms a striking contrast with the rest of the red-looking fundus. The blood-vessels, especially the arteries, are smaller and may sometimes become entirely obliterated; but the rest of the retina may present a perfectly normal ophthalmoscopic appearance. In course of time the atropic changes of the papilla may result in obliteration of the nerve-fibres and this leads to a uniform depression of the optic papilla, which is known as an atrophic excavation. The appearance of the papilla varies according to the nature of the degenerative process; it may appear perfectly white if the nerve-fibres are replaced by cicatricial tissue, or it may present a gray, dotted appearance, which is due to the fact that the perforations of the lamina cribrosa, that served for the passage of the nerve-fibres, become visible, because the latter become completely atrophied and the inflammatory products are absorbed. This appearance is sometimes met with in perfectly healthy discs, but it occupies then only a part, usually the central one of the disc, and is due to the fact that the nerve-fibres begin to spread at the outer side of the lamina cribrosa already. This is therefore always accompanied by a central depression known as a physiological cup or excavation.

The only symptom of the disease is impaired vision; this is generally central, but there are also defects of the field of vision; these are especially in the region of the blind spot (see page 238), because the exudation is usually located around the optic papilla. The disturbance of vision depends to a great extent upon the lesions of the nerve-fibres; there may be a great deal of œdema and an immensely swollen papilla and perhaps hardly any impairment of vision; on the other hand, we may have apparently slight changes of the disc, but these may affect principally the nerve and result in great impairment of vision; this is especially the case in the next variety, neuritis descendens.

In regard to the prognosis it is impossible to say what the ultimate result will be. It is, as a rule, grave if the retinal arteries are much affected and greatly reduced in size, and when the central artery has become entirely obliterated, there is not the slightest chance of saving much sight. The appearance of the disc is also of great importance. The gray punctate disc, generally known as *gray atrophy*, offers very poor chances of improvement. The longer the condition existed the more unfavorable will be the prognosis.

The causes of neuritis ascendens are generally those that lead to a dropsical distention of the nerve-sheath; these are mostly cerebral affections that are associated with increase of the intracranial pressure, and of these tumors of the brain, or intra-cranial gummata are perhaps the most frequent. It is not necessary that the tumor should press directly on the nerve or affect the nerve-centres, but it is the increase of the intra-cranial contents. Distention of the ventricles, also meningitis, acute as well as chronic, also that variety due to syphilis, basilar meningitis, extensive cerebral hemorrhage, and even intra-cranial aneurism, may give rise to neuritis. It is mostly due to coarse lesions of the brain, but it has been observed with widely diffused minute lesions. Such diseased conditions will generally lead to an affection of both eyes and are apt to be associated with a wide pupil; but those cases due to orbital processes or to hemorrhages into the nerve-sheath will be observed in one eye only. Cerebral tumors may at times lead to affections of one eye. It is, however, difficult to locate the seat or to determine the nature of the cause by the appearance of the optic disc or the pupils, and it is also probable that in many cases of neuritis ascendens, or better, papillitis or chocked disc, there is at the same time a neuritis descendens travelling down from the brain in the tissue of the nerve.

It has been claimed that obstruction of the venous circulation, due to compression of the ophthalmic vein, might lead to papillitis; but this is hardly possible, because the central vein of the retina empties directly into the cavernous sinus, and only compression of the nerve itself can cause these changes.

Treatment.—As the cause is usually a cerebral affection, the main treatment has to be directed to these lesions. The most favorable results are obtained in those cases that are due to syphilis; as they are mostly tertiary manifestations, large doses of iodide of potassium are called for, twenty to sixty grains of it may be given three times a day, or if this fails, a twenty-fourth of a grain of the bin iodide of mercury may be added to each dose. Leeches and Hœurteloups are of doubtful value, but it has been proposed (Wecker) to open the sub-vaginal space of the optic nerve, by cutting the outer or dural sheath by means of scissors, which are introduced between the capsule and the eyeball. As soon as the incision is made the fluid causing the pressure will escape. Of course great care must be used not to divide the nerve itself, and as even in the most favorable cases the relief would probably be only temporary, it would hardly be advisable to perform such a dangerous operation, except in very violent cases.

3. *Neuritis descendens, Retro-bulbar neurititis.*—This is an inflammatory process of the optic nerve itself; in rare cases the inflammation starts from the nerve-fibres, but it is generally an affection of the connective tissue elements of the nerve. It may sometimes originate within the nerve itself, but in nearly all cases it is due to an extension of an inflammation of other tissues to the nerve, and may be caused by encephalitis, by a meningitis, or by an extension of orbital processes to the nerve.

The ophthalmoscopic appearances of this variety of neuritis are not so marked as we see them in neuritis ascendens; but they may resemble those of a mild case of papillitis; there is a slight amount of œdema of the disc and the surrounding retina, which manifests itself by a blurred appearance of the margin of the papilla; there is also marked hyperæmia of the nutrient vessels of the optic nerve and also of the retinal vessels; especially the veins are tortuous and distended; the arteries are often diminished in size. In many cases the appearance of the papilla differs but slightly from that of a healthy eye, perhaps there is only the outer half of the optic disc changed, which looks paler than a normal one.

This affection occurs often suddenly, and is then apt to be associated with wide pupils and sudden blindness. It is especially apt to occur after severe constitutional diseases and after lead-poisoning, or it is connected with disturbed menstruation. I have seen it also occur during pregnancy. The disease may pass off without serious disturbance of vision, but in the majority of cases it results in atrophic changes of the nerve. Milder cases of neuritis have been observed when the disease lasted but a short time and ended in perfect recovery. The treatment of this affection is even more unsatisfactory than that of neuritis ascendens, and must, like this, vary according to the cause. In the latter part of the disease hypodermic injections of strychnia may give surprisingly good results.

4. *Atrophy of the optic disc* (Figs. xxxiii. and xxxiv.).—We have seen in the preceding lines, that inflammatory conditions of the optic nerve may result in atrophic changes of the nerve-fibres. As the inflammation is usually accompanied by great disturbance of the nutrition of the nerve, its nutrient vessels having been destroyed or greatly contracted during the inflammatory process, atrophic changes are apt to occur. In many cases the disturbance of nutrition, and also the atrophic changes, may affect only the lower, intra-ocular portion of the nerve; this is apt to be the case after papillitis (Fig. xxxvi.). In other cases the atrophic changes may be due to a change of the blood-vessels supplying the cerebral portion of the nerve. These vessels are branches from the vessels of the pia-mater and the brain. The atrophic changes may be caused furthermore by compression of the nerve-fibres by inflammatory products, by those of a neuritis ascendens as well as those of a neuritis descendens; in the latter case a large portion of the nerve may be implicated; this is called a consecutive atrophy. Atrophic changes of the optic nerve are also seen with diseases of the retina and choroid of long standing. This may be due to an extension of the inflammatory pro-

cess to the nerve or it may be due to a disturbance of the nutrition of the nerve, caused by the atrophic changes of the blood-vessels of these parts. Again we meet with cases where the atrophic change was brought about by compression of or by pressure on the optic nerve. This may occur within the cranium and may be due most frequently to tumors, to cerebral hemorrhages, to hydrocephaloid changes or localized inflammations. The nerve may also be compressed in the optic foramen or within the orbit by tumors and inflammatory products. In a great many cases, however, no cause can be assigned for the atrophic change.

Symptoms.—The sight of the patient begins to fail gradually; the central as well as the peripheral vision is affected. The condition of the field of vision is of great importance, and it should be mapped out in each case. We meet with cases where the field of vision is irregularly or uniformly contracted, where the central vision alone is affected, or where only a part of the field of vision is absent.

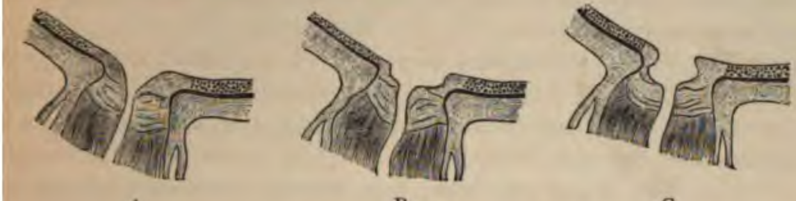
Again, we meet with cases where one half of the field is absent, this is called hemiopia or hemianopsia. According to the seat of the lesion, the temporal or nasal side of one or both eyes may be affected. If, for instance, the lesion is located in the occipital lobe at a point indicated on diagram, page 285, as 1, which is on the extreme right side of the brain; the fibres, that take their origin here, are the peripheral fibres of the right tract, and go to the right side of the retina of the right eye, they must become implicated, and the result will be a paralysis of the right or temporal side of the right retina. The right eye will, therefore, become hemiopic, and objects to the left or nasal side of the field of vision are not seen by the patient. If the cerebral disease is situated at 2, which is nearer to the median line, it implicates the inner and central fibres of the right optic tract. These are the ones that decussate at the optic chiasm and go to the right side of the left eye; they will cause a loss of function of the right side of the retina of the left eye, and the patient's temporal half of the field of vision of this eye will be absent. If the lesion is at 3, the effect will be felt on the nasal side of each eye, because fibres of the right as well as of the left tract will be affected, and the result will be a defect of the temporal side of the field of vision of each eye; this is known as temporal hemiopia. In a case of compression of the right optic tract, at 4, by a tumor for instance, the effect will, after the decussation of the nerve-fibres, be felt on the right side of each eye and result in equilateral or homonymous hemiopia. A compression of the optic nerve itself, however, at 5, which might take place in the optic foramen or in the orbit, would naturally result in complete blindness of the ight eye. If the compression, due to a blood-clot or tumor, hould occur at 6, in front, or at 7, just behind the optic chiasm, he result would be the same as if the lesion was at 3; the ner fibres of both nerves would be affected, resulting in inac-vity of the nasal side of each retina, and consequently in tem-oral hemiopia (Munk). In testing the patient's field of vision r these affections, it is better to resort to the use of a black-oard or perimeter (see page 236). Further investigations in is direction, based upon carefully conducted post-mortem ex-minations of hemiopic patients, would be of great value, and ould help to illustrate the mode of decussation of the optic erve-fibres. At present it is hardly possible to locate exactly he seat of a cerebral lesion from the condition of the eyes only.

There is no pain or other unpleasant symptom accompanying he disease, except that a delicate haze appears to be spread ver the patient's sight; this becomes dimmer in the course of ime, and the process may end in complete blindness. This dis-ase attacks generally both eyes, but one eye alone may be ffected, and in these cases the atrophy is probably due to orbital ffections, or to an embolus of the retinal artery, or to intra-cranial umors (page 277.)

Atrophy of the disc is sometimes accompanied with wide upils, and again we see it with extremely narrow pupils. The rmer is usually associated with some cerebral disturbance; the tter is often seen, if the disease is due to spinal lesions, especially o affections of the posterior columns of the spinal cord, to loco-otor ataxia or tumors for instance. In atrophy due to posterior pinal sclerosis (Fig. xxxiii.), we have complications of different ortions of the nervous system besides those of the optic nerve. ne nerve may be affected first, and later the other eye may suffer kewise, or both nerves may become diseased at the same time. ffections of the optic nerve are seen only in a limited number f cases of locomotor ataxia, and are generally among the earlier ymptoms of the disease; it is frequently accompanied by para-tic affections of the ocular muscles.

The pathological changes of the nerve in atrophy are due ither to total destruction of the nerve-fibres, or to an atrophic ondition of these nerve-elements, especially in the optic papilla. he whole circumference of the nerve is less than usual, and its bres may be like a thin thread, or they are sclerotic, or as said efore, they may be entirely absent. The connective tissue portion of the nerve is generally markedly hypertrophied and forms at the papilla a network of areolar connective tissue, but there are no nerve-elements present, and the nutrient vessels may have disappeared entirely.

The ophthalmoscopic appearance of the optic disc is very characteristic: 1, the nerve looks blanched and at times very white; 2, its outline is sharply defined; 3, it is flat or shows a uniform depression (*atrophic excavation*); 4, the nutrient vessels of the nerve cannot be seen, but the retinal vessels, arteries as well as veins, are as a rule only slightly changed; the arteries are apt to be a little smaller than in the normal condition. 5. Sometimes the papilla has a grayish punctate appearance, which is due to the fact that on account of the atrophy of the nerve-fibres the lamina cribrosa and its perforations become visible. A similar appearance, however, is also seen in normal eyes (page 232). We have sometimes atrophic conditions in which the nerve has a bluish look. In regard to the diagnostic importance of these different conditions, it may be said, that a very white disc with diluted pupils would point toward cerebral causes and that a bluish disc with contracted pupils might be the result of spinal lesions. An atrophic disc with ill-defined outline is generally due to a preceding neuritis, and one with great changes, diminution or disappearance of all, even of the retinal vessels, is often the result of extensive diseases of the retina or choroid. In regard to the atrophic cupping of the optic papilla, it is well to remember that extensive excavations may be seen in perfectly normal eyes, which are called physiological cups, and that only very few eyes are without a slight central depression (page 232). The differential diagnosis, however, is not very difficult, because not only the defective vision, but also the disappearance of the nutrient vessels of the papilla and the even, uniform depression would indicate atrophy; a physiological cup is conical in shape, the apex of the cone extending to and even beyond the lamina cribrosa, and the vision is not affected. Another kind of excavation, also the result of disease, and also frequently accompanied with great impairment or even total loss of vision, is the so called "pressure excavation." It is the result of glaucoma, and is due to the effect of a great increase of the intra-ocular tension, which is followed not only by atrophy of the nerve-fibres, but also by bulging outward and distention of the lamina cribrosa. As the intra-ocular portion of the orifice, which is formed by the hard unyielding scleral ring, does not change, such an excavation may extend considerably behind this ring of scleral tissue and is more or less bottle-shaped. The following diagrams may serve to explain these different conditions:



A represents a physiological, B an atrophic, and C a glaucomatous cup.

The shape of the excavation is frequently best seen by the course of blood-vessels. In a physiological cup (Fig. A) they ascend in a slanting direction, and making a simple curve over the edge of the scleral ring, pass into the nerve-fibre layer of the retina; their entire course can be seen in most cases from the lamina cribrosa to the retina. In an atrophic condition (Fig. B) they are apt to run at the bottom of the excavation, and then, making a sharp curve, pass over the scleral ring into the retina; they have to describe therefore a double curve, one at the point of entrance and one as they leave the optic disc. In a glaucomatous or pressure-excavation (Fig. C), the blood-vessels will disappear for a short distance, which is due to the fact that the cupping of the disc extends behind the scleral ring; the vessels are therefore not seen at this point; they appear broken, and become visible again just before they curve over the scleral ring in order to reach the retina. There is at times apparently no connection whatever between the vessels before and after their disappearance. This peculiarity is often seen only in a small portion of the disc, which is usually the temporal one, and the rest of the vessels may appear perfectly normal.

In regard to the prognosis, which is always grave, it may be said that an irregular contraction of the visual field, or a large defect of it are unfavorable; equilateral hemiopia is more favorable, because the unaffected nerve will probably remain intact, but in temporal hemiopia there is great danger that the lesion might be progressive and affect both nerves. This rule does not, however, always prove true, and cases of temporal hemiopia, especially if due to traumatism or hemorrhage, may make tolerably good recoveries. Atrophy following neuritis is also quite hopeless; the same may be said if it is secondary to diseases of the retina or choroid, and if the retinal arteries have undergone great changes and are reduced in size.

The treatment of atrophy of the optic nerve is very unsatisfactory. The administration of large doses of iodide of potassium in specific lesions, or the hypodermic use of strychnia in other cases may cause a favorable change. The main object must be to treat the causes of the disease. Local applications of the artificial leech, the use of the galvanic current, and occasionally the administration of a strong cathartic, may be of great service in some cases.

5. *Amblyopia and amaurosis.*—In former times all diseases of the deeper portions of the eyeball, viz., of the retina, the optic nerve and choroid, of which the only demonstrable symptom was impairment of vision, were classed under this heading. Thanks to the aid of the ophthalmoscope, the study of these diseases is more satisfactory, and we class amongst the amblyopic affections only those cases of impaired vision that are not associated with any visible ophthalmoscopic changes of the fundus, and are not due to errors of refraction that can be corrected by glasses. The term amblyopia, which means *dull eye*, and amaurosis, which stands for *to render obscure*, are used according to the degree of the impairment of vision; if the visual power of an eye is reduced, even to such an extent that only very large objects are seen, it is expressed by amblyopia; but if there is only very faint perception of the light of a candle, or if the patient is only able to distinguish between light or darkness, or is totally blind, he is called amaurotic.

Amblyopia is met with under different circumstances and is often progressive. The development of these affections, which are generally found in both eyes, is greatly favored by a poisoned or vitiated state of the blood, which exerts a toxic effect upon the retina and the optic nerve, or leads to disturbance of the nutrition of the nerve-elements of these parts. The toxic influence may be due to (1) urea, (2) lead, (3) quinine, (4) liquor, and (5) tobacco. Sometimes the toxic effect is felt after excessive use of otherwise harmless agents, especially if a lowering of the general health acted as a predisposing cause. This is often seen after the unrestrained use of tobacco and liquor and also after the administration of large doses of quinine; it is then called *amblyopia ex abusu*. A number of symptoms pointing to a disturbed or sluggish circulation, such as headaches, cold feet and hands, and obstinate constipations are frequently seen to precede or accompany this affection.

1. Amblyopia may be met with in uræmic conditions during the later stages of Bright's disease, when no changes of the

retina or of the optic nerve can be seen; it is always a grave symptom.

2. Cases of lead-poisoning, accompanied by almost complete loss of sight, have been noticed in considerable number, not so much among painters, as in workmen employed in the lead mines of the Western states.

3. Quinine-amblyopia has been noticed not only after the administration of large doses of quinine, but also after the excessive use of Peruvian bark (Roosa); it is generally only transient.

4. After excessive and long continued use of liquor amblyopic affections are of frequent occurrence. Both eyes are generally affected, but not always to the same extent; the vision is as a rule not greatly reduced; it varies generally between $\frac{2}{5}$ and $\frac{1}{20}$, and there may be other symptoms of alcoholism, such as trembling of hands, or even delirium tremens. In cases of long standing amblyopia there may be a blanched condition of the outer half of the optic disc, but generally no lesions of the fundus can be seen. The patient who notices the impairment of vision, generally after a debauch, is of course greatly frightened; but as a rule the disease will not lead to blindness.

5. Abuse of tobacco is not such a frequent cause of amblyopia; it seems to be caused especially by the use of pipe-smoking, and is more frequently seen in persons whose occupation keeps them confined in badly ventilated rooms and without much exercise, for instance, tailors and shoemakers, or in persons that are poorly nourished and keep mostly in doors; old and feeble men are therefore most apt to suffer from the poisonous effect of tobacco. In the beginning of the trouble slight hyperæmia of the optic disc, and later, slight atrophic changes of the outer half of the optic papilla, which has also an indistinct, muddy appearance, have been frequently noticed in this affection. It is, however, seldom that we have occasion to see the bad result of either tobacco or liquor alone; they have been used or rather abused by such patients generally together. English surgeons seem to attach most of the blame to the effects of tobacco, but in our country it seems to be the general belief of ophthalmic surgeons that liquor is the most frequent cause of amblyopia. Such patients may have indulged more or less freely in liquor and tobacco for many years, with apparent impunity, when all at once, after a lowering of the tone of the system, or frequently without assignable cause, the sight becomes impaired.

Amblyopic affections are also produced by a lowering of the general health, especially by a poor condition of the blood; in anæmic patients or after hemorrhages, especially from the uterus, but also after bleeding following the extraction of a tooth, great reduction of the visual power may be noticed ; a similar condition has been noticed after profuse secretion of other fluids, draining the system continually; as for instance, in large suppurating wounds. After long continued masturbation, and even after frequent nocturnal emissions, amblyopic affections have been noticed; these are generally preceded or accompanied by mouches volantes and dizziness. In these cases the power of accommodation is likewise greatly impaired (Hutchinson). Amblyopic affections may also be congenital or hereditary, and affect in this case one or both eyes. If one eye alone is amblyopic, it is frequently due only to a local and not to a constitutional cause, and this may be non-use of the eye, or it may be due to the formation of indistinct retinal images, as it occurs in cases of faulty refraction of the eye that have never been properly corrected, or perhaps can not be corrected on account of irregularity of the curvature of the cornea. Amblyopia ex anopsia from non-use of the eye, is of frequent occurrence in old cases of strabismus. (See page 69).

Symptoms of amblyopia.—The principal symptom is the impairment of vision; this, if both eyes are affected, will soon be noticed by the patient; but if only one eye is amblyopic, this condition may have existed since birth and the patient not be aware of it until he attempts to see with this eye alone, or if a slight trouble of the good eye, which prevents its use, will call the patient's attention to it. In strabismus the patient usually supposes that he can see perfectly well with both eyes, until each eye is tested separately. The defective vision is apt to be noticed more in bright light than in the dark, and such patients see better in the morning or evening than in the middle of the day. Of the greatest importance is the impaired perception of colors in this affection; it is called acquired color-blindness, because the patient recognized colors before the attack correctly. The color-blindness varies in the different parts of the visual field. The central perception may be quite normal, but as soon as the colors are removed farther away from the point of fixation, they become indistinct. Green is usually the color that is seen in the smallest circle of the field of vision, red is recognized in a larger space, and blue and yellow may have a field only slightly contracted. Frequently there is a central defect of the field of vision, but a contraction of the field, is not often seen. The disease is mostly seen in men, because they are more exposed to the causes.

The prognosis is good in those cases due to toxic influences, if they have not been at work too long, and if the patient's vision is not greatly reduced. In favorable cases perfect recovery may take place, but as a rule, a slight amount of impairment of vision remains. There is, however, in constitutional cases a very grave prognosis; such patients are not in danger of becoming totally blind, they may always be able to go about without any trouble, though they may find it difficult to recognize their friends; this ability to go about is generally favored by the fact that their field of vision is not contracted, that their peripheral vision is tolerably good.

Treatment.—In all cases of amblyopia the cause of the affection should be an indication to the mode of treatment. In uræmic poisoning for instance, the vapor bath and other remedies for Bright's disease should be used. In cases of lead-poisoning the iodide of potassium is one of the best remedies we have, and the patient must avoid the cause by seeking other employment. Cases of quinine-amblyopia generally make a perfect recovery. In abuse of alcohol and tobacco, no spirituous beverages of any kind, no tobacco, not even beer or strong coffee should be allowed to the patient. If these cases are under careful treatment and are improving, it is surprising to see what a change for the worse may be brought about by a single glass of beer or liquor. Together with this it is necessary to improve the general condition; attention to the circulation and the state of the bowels is absolutely necessary. Of the greatest value is the use of strychnia in these cases, it should be administered hypodermically in increasing doses; from $\frac{1}{32}$ to $\frac{1}{8}$ of a grain daily, to be applied to the temporal region. If the patient cannot be seen daily, $\frac{1}{32}$ of a grain of strychnia may be given by the mouth, three times a day, to be taken before meals. ℞. Strychniæ, gr. i, aquæ ℥ iv. S.—Dose a teaspoonful. Electricity is also of great help; the galvanic current should be used every other day from five to ten minutes at a time. But all these remedies will be of little service if the patient keeps up his bad habits. Total abstinence is absolutely necessary.

Amblyopia congenitalis cannot be relieved, but amblyopia ex anopsia can be greatly benefited by the systematic use of the eye. The good eye is to be bandaged for a certain time every day and the affected eye is to be used alone for reading as well as for other work, during this time. A perfect cure is not likely to be accomplished even after an operation for the squint.

Pretended blindness, malingering.—If called upon to decide about real or pretended blindness of an eye, we may encounter great difficulties, if the pretender positively denies that he can see anything. There are several modes of detecting this: 1. Give the patient something to read, fine print is preferable, and hold, as if by accident, a lead pencil or penholder between the print and the patient's eyes. If he continues to read fluently, he must see with both eyes; if he is blind in one eye, a portion of the print will be covered by the pencil and cannot be seen. 2. Hold a strong prism with the base up or downwards before the patient's good eye; this will make him see double, if he sees with both eyes; if he sees with but one eye he will see only one object. 3. Another very good test is to put a drop of atropine into the good eye, and after the pupil has become fully dilated let him read fine print; if he is able to do this, he must see with the other eye which he says is blind. 4. Give the patient a pair of glasses to read with, which bring a ground opaque glass before the good eye and a plain glass before the "blind" one; if he reads with these glasses he cannot be blind in that eye. 5. The relation of the pupil of the eye that is supposed to be blind, to the effect of light is also of importance. Close the patient's good eye and shade the other eye alternately; if the pupil reacts promptly, the eye cannot be very much affected. In pretended blindness of both eyes, this state of the pupils in light and darkness is perhaps one of the best signs to detect the real condition of the eye.

6. *Tumors of the Optic Nerve.*—They are of rare occurrance, and may be cystic tumors, carcinomata or neuromata. These tumors may develop in the orbital portion of the nerve or they may attack the nerve within the cranial cavity. The symptoms are sometimes exophthalmus and always greatly impaired vision. The ophthalmoscope reveals a marked retinitis, with intense hyperæmia of the vessels and great enlargement and thickening of the papilla, which may project far into the eye. These tumors call for an operation, which should be a removal of the tumor alone, if it is a benign growth and an enucleation or even exstirpation of the contents of the orbit, if the tumor appears to be of a cancerous variety.

CHAPTER XVI.

GLAUCOMA.

THIS disease has derived its name from "*glaucos*" *green*, on account of the greenish reflex of the pupillary space, which is seen in some cases of this affection. The principal feature of the disease is however an increase of the intra-ocular tension of the eye-ball, which is due to a disturbance of the harmony of secretion and excretion in the interior of the eyeball, resulting in an increase of the fluid contents of the eye; it becomes hard to the touch. This increase of the intra-ocular tension leads to the development of numerous well-marked and more or less prominent symptoms and to certain pathological changes.

According to the manner in which the disease manifests itself, we may adopt for clinical purposes the division of the glaucomatous processes into: 1, *acute inflammatory*, 2, *chronic inflammatory*, 3, *simple*, and 4, *secondary glaucoma*.

There are a number of symptoms which are found in all glaucomatous conditions and are the essential characteristics of this disease.

1. *Impaired central vision.*—This symptom varies in different cases considerably; it may be but little affected in the beginning and even after very acute attacks there may be but slight impairment of vision; but this must not lead us astray; the vision will eventually become worse and worse and will, if the disease is not relieved in time, surely lead to blindness. At other times vision may be entirely destroyed in a single attack. In other cases there will be such a gradual loss of vision that if it affects one eye only, the patient may be nearly blind in this eye and yet be hardly aware of it.

2. *Impaired peripheral vision.*—This will be always met with in these affections and especially a contraction of the nasal side of the field of vision is very characteristic of glaucoma. In advanced cases this defect of the field of vision may be so marked that the patient can hardly count fingers on the nasal side; but in the beginning and in doubtful cases the slightest impairment of the nasal side of the field may be of diagnostic value. Later

in the disease the field of vision becomes contracted from all sides.

3. *Increase of tension of the eyeball.*—This may be so slight in some cases of glaucoma simplex, that it is hardly noticed, even if the sight of the eye has been totally destroyed; but as a rule this is one of the most striking symptoms of the disease, and the tension may vary from t + 1, where the eye is only a little harder, to t + 3, when there is stony hardness of the eyeball. If the other eye is not yet affected by the disease, the contrast of the two, if tested at the same time by placing one hand on each eye, is especially striking.

4. *Glaucomatous excavation of the optic disc.*—This is the most reliable sign of a glaucomatous condition and the best proof, that there has been an increase of the intra-ocular tension at some period of the disease, even if it is not present at the time of the examination. The nature of the glaucomatous excavation is seen by the dipping of the blood-vessels under the scleral ring, so that a certain portion of their course is not visible on examination with the ophthalmoscope, and it is especially on this account, that the glaucomatous excavation differs from the atrophic and physiological excavation of the optic disc. (See page 297.) The glaucomatous excavation is as a rule deeper and larger in circumference than the other excavations, and it may be more than 2 mm. deep.

5. The excavation is accompanied by atrophic changes of the disc; the nerve looks white, the small nutrient vessels of the papilla have disappeared and even the retinal vessels may show slight changes.

These five symptoms are to be found in all the different glaucomatous conditions, but they may be more or less pronounced in some cases. A number of other symptoms are peculiar to special cases and will be described later.

Glaucoma is a disease of advanced age, when the sclera has become hard and little distensible, and is rarely met with in childhood. It will generally affect both eyes, but it is seldom that the two eyes become affected simultaneously and considerable time may elapse after the development of the disease in the one eye, before the other begins to suffer. It is more apt to attack eyes with a thick, rigid sclera and is therefore of more frequent occurrance in hypermetropic than in myopic eyes. The sclera is in the latter condition thin and yielding. The disease may be hereditary, affecting at times many members of one family. An attack of it may be brought on by certain exciting causes such as excesses of any kind in liquor, tobacco or venery. It is seen also sometimes after excessive use of the eyes, after fatigue or a lowering of the tone of the general system, for instance during the period of lactation, or after severe nervous shocks; sometimes it is seen to develop suddenly after an operation for the same disease of the other eye, and also after the use of atropine. It is of greater frequency among certain nationalities and is met with in Europe more frequently than here; there glaucoma is seen in more than one per cent of all eye diseases; here it is found only in a little less than in one-half per cent.

As said before, the increase of the intra-ocular tension is caused by a disturbance of the harmony of secretion and absorption. It may be that the secretion is more than normal and that the absorbents cannot carry this off, or these latter may be at fault; they become less active on account of changes in the tissues, or these channels become compressed and partly obstructed. In the first place the hypersecretion may be caused by irritation of the Trigeminus (Donders) or it may be due to an interstitial hyalitis (Hassner). But the absorbents are more frequently at fault; this may be due to various causes; for instance, it may be due to a rigidity of the sclera, which interferes with the perfect balance of the circulation by compression of the veins, and to great changes of the cornea (Stellwag), or it is due to changes of the spaces of Fontana (see page 115), which become impermeable or compressed; these spaces are near the sclero-corneal junction and through their agency the filtration of the aqueous humor takes place into the venous plexus, which is also in this location, and into the canal of Schlemm. A swelling lens, for instance, may push the iris forwards against the cornea and the spaces of Fontana become compressed. The ciliary processes play also a very important part in the pushing forward of the iris.

Ophthalmoscopic changes of glaucoma. On account of the increase of the fluid contents of the eyeball, this becomes harder; and as the sclera and the cornea are firm and resistant, the increase of the pressure is felt especially at the entrance of the optic nerve. The lamina cribrosa is much thinner and less resistant than the surrounding sclera and is apt to give way gradually. The nerve-fibres, which turn here almost at right angles in order to reach the retina, suffer from the long-continued pressure; they become atrophic. The pressure is felt especially at the most exposed portion of the disc and retina, and at their outer half the nerve-fibres will undergo slight atrophic changes in the earlier stage of the disease; this accounts for the early contraction of the nasal side of the field of vision, which increases with the atrophic changes of the nerve. The blood-vessels of the disc become compressed and eventually obliterated; the retinal vessels also suffer from the pressure, the arteries become smaller; it requires great blood-pressure to overcome the intra-ocular pressure and this results in a distinct pulsation of the arteries, which is seen as they pass over the optic disc, beginning at the centre of the papilla. The retinal veins on the other hand become distended, large and tortuous and even small retinal hemorrhages may be present; the pulsation of the veins becomes likewise more apparent; it begins at the periphery of the disc. The latter is not a very characteristic sign of increased tension; it is often seen in perfectly healthy eyes; but the pulsation of the arteries is only noticed in cases of increased intra-ocular tension and may be produced at will by compression of the eyeball with our fingers.

If the pressure continues the lamina cribrosa will yield, but the hard, resisting scleral ring will not change; the result will be a bottle-shaped depression, wide at the bottom and contracted at the top (see page 297). The blood-vessels will be forced to the bottom and sides of the excavation, they dip under the edge of the sclera before they pass over it to the retina; this explains why they are lost to view in a part of their course. They can be seen at the bottom of the excavation for a short distance, then they disappear under the edge of the scleral ring and leavto the atrophy of the nerve-elements and the distention of the lamina itself.

These are the appearances which we see by means of the ophthalmoscope, if the refractive media are clear and permit an examination of the fundus. But the long continued pressure will also result in changes of other parts of the globe. The little groove seen at the sclero-corneal junction becomes obliterated and the eyeball appears more globular. The increase of the intra-ocular fluids is especially due to an increase of the elements of the vitreous body, which, at times, may also become more or less cloudy. The lens and the iris may be pushed forwards to such an extent, that the latter comes almost in contact with the posterior surface of the cornea, and the anterior chamber is very narrowed. The iris itself cannot act as freely as usual; it is sluggish in the beginning, and in old cases atrophic changes of the iris take place, which may, in course of time, be reduced to a thin band. The pupil is moderately dilated and has often a greenish reflex; glaucoma however will never lead to the formation of posterior synechiæ, and if these are present, they must be due to a preceding iritis.

The cornea, if pressed upon in the normal condition, will be rendered somewhat opaque, and this is what takes place if the glaucomatous tension becomes very marked. The cornea will then present a diffuse hazy appearance, it has a steamy look, and this will make an ophthalmoscopic examination of the interior of the eye impossible. The ciliary nerves suffer also from the increase of the intra-ocular pressure and the cornea will become anæsthetic. We may touch it with a fine object, a piece of paper for instance, and the patient will not feel it, he will make no effort to close the eye; in the normal condition, if any foreign substance touches the cornea, it will cause a prompt spasmodic closure of the lids, and the patient will feel it distinctly.

The ciliary muscle, which is also supplied by the ciliary nerves, must suffer likewise; in the beginning of the disease accommodative efforts become difficult and in the later stages almost impossible on account of the paretic condition of the muscle. This is the reason why patients suffering with the premonitory stage of glaucoma require the use of strong convex glasses, which have to be exchanged frequently for stronger ones, for reading or near work.

As might be expected, the blood-vessels of the eye undergo also certain changes during the course of the disease; of the changes of the retinal vessels we have spoken before, the arteries become a little smaller and pulsate, and the veins become tortuous and large. The choroidal veins are also distended, and the venæ vorticosæ as they perforate the sclera are apt to become compressed, which will necessarily again serve to increase the intra-ocular tension, and a large portion of the blood has to leave the eyeball through the anterior ciliary veins near the sclero-corneal junction; these vessels become distended and cause the faint ciliary injection, so often seen in marked cases of glaucoma. As these veins anastomose freely with the conjunctival veins, quite a number of them become also engorged and very prominent. The ciliary body is also congested and especially the ciliary processes, being very vascular, become considerably enlarged.

A. SIMPLE GLAUCOMA.

A glaucomatous attack, not secondary to other diseases of the eye, may come on very slowly and without any external manifestations. This is called glaucoma simplex. The disease affects frequently one eye alone for a long time before the other eye begins to fail, and the fact, that the eye is almost blind, may have been discovered only accidentaly, because it has given the patient no inconvenience whatever. We have in these cases the five principal symptoms, due to the increased intra-ocular pressure, which have been mentioned in the beginning, more or less prominent. 1. There is greatly impaired vision. 2. The field of vision, especially the nasal side, is apt to be contracted. 3, There is increased tension of the eyeball, but this may not be very marked. 4. The glaucomatous excavation is often the most reliable sign of this affection. 5. The atrophic changes of the optic papilla are marked; there is a very pale, anæmic disc.

From a simple atrophy of the optic nerve these cases differ on account of the peculiarity of the excavation (see page 297) and if there is enough sight to test for the field of vision, by the fact that in glaucoma the nasal side of the field is especially contracted, whilst in atrophy we have a general though sometimes irregular limitation of the field of vision, and the temporal half may often be the principal seat of the contraction.

B. ACUTE INFLAMMATORY GLAUCOMA.

Frequently the conditions, resulting in an increase of the intra-ocular tension, are accompanied and followed by acute inflammatory symptoms, and especially in those cases where there is a rapid increase of the intra-ocular tension, the inflammatory manifestations are very marked and some of the subjective symptoms, chiefly the pain, very intense.

These attacks may come on very suddenly without warning, but they are often preceded by a more or less marked prodromatous stage. This period is generally characterized by difficulties of accommodation, especially in hypermetropic eyes, such persons requiring a frequent change of their glasses for stronger ones; by sudden obscurations of vision lasting only a short time, by the appearance of phosphenes, such as colored rings around the light, slight contractions of the field of vision and by periodical increase of tension. The premonitory symptoms are mild and periodic in their appearance and may continue for a long time. An acute attack may however be very sudden; the patient may retire well in the evening and wake up in the morning with a severe glaucomatous attack of one of his eyes. Such an attack is generally due to some exciting cause, (see page 304) such as taking cold or excessive use of the eye or intemperance; it may come on after the use of atropia and at times after an operation on the other glaucomatous eye, as mentioned before.

The inflammatory symptoms manifest themselves by intense hyperæmia of the ciliary vessels; there is marked ciliary injection (Fig. xvii) and also the conjunctival vessels are congested to such an extent, that the disease might easily be mistaken for a severe case of conjunctivitis or for an iritis. There may be also chemosis and even œdema of the lids, but there is no conjunctival discharge; there is however marked photophobia, intense photopsies, and lachrymation. The eyeball is during these attacks stone-hard and also very sensitive to the touch. There is further intense ciliary pain. The sudden increase of the intraocular contents within a space surrounded by the hard resisting sclera and cornea, must cause great pain within the eye by the the compression of the ciliary nerves; but also the reflex pain of the different branches of the fifth nerve is very severe.

This is often accompanied with vomiting and other constitutional disturbances. The compression of the nerves is also the cause of the anæsthetic condition of the cornea, which can be touched with a piece of paper without causing any reflex action on the part of the lids, nor does the patient feel it. The cornea is also hazy, and the aqueous humor is quite cloudy. The lens and iris are pushed forward and the anterior chamber is much smaller; the iris is congested and discolored. The pupil is somewhat dilated, and the reflex of the pupillary space is of the characteristic greenish appearance. The vitreous body may be cloudy, and it is generally impossible to observe the condition of the fundus. The vision of the patient is greatly reduced and may be in some cases entirely destroyed within a few hours.

These acute attacks last generally only for a short time, from a couple of hours to several days, and are followed by a period of remission; the symptoms subside gradually; the patient is able to open his eye, as there is no photophobia, and the pain and injection disappear. The sight, if it has not been destroyed during the attack, which is of rarer occurrence, improves rapidly, but it will seldom become as good as it was before the attack, and the defect of the nasal side of the field of vision will become more marked. The transparent media clear up and the fundus becomes visible, and frequently there are some slight changes of the disc, especially a slight excavation of the papilla, to be seen. After a shorter or longer period of ease there will be another attack, brought on by similar exciting causes as the first, especially by fatiguing work.

These attacks are all more or less violent, and result always in a more marked reduction of sight and narrowing of the field of vision, until the patient is nearly blind. The period of remission varies considerably in these cases, and the disease may last for years, until it ends in complete blindness, or *absolute glaucoma.* But even in perfectly blind eyes, acute and extremely painful attacks may make their appearance; they are accompanied by increase of tension and marked phosphenes, there are flashes and flames of light before the patient's eyes.

C. CHRONIC INFLAMMATORY GLAUCOMA.

In this form of the disease the process is similar to that of the acute variety, only that it extends over a long space of time, and that the inflammatory symptoms are very slight and may be frequently overlooked. There are however often slight exacerbations of the disease, when a fog seems to come over the sight of the patient; they are apt to be followed by some reduction of vision. These attacks come on after excessive use of the eyes or after great mental depression, and are generally of short duration, and the patient has slight phosphenes during the attack; the light of a lamp is surrounded by circles of colored light. In other cases the disease progresses more uniformly, but there may be slight changes in the sight of the patient at different times. In some cases the disease is preceded by an acute attack, and there are more or less marked subacute ones during the course of the disease, when the eye flushes up, and shows slight ciliary and conjunctival injection.

The tension of such an eye is not very marked, perhaps there is t+1; the pupil is moderately dilated and the anterior chamber is narrow. The cornea may be cloudy at times and clears off again, according to the nature of the case. The vision is gradually getting worse, and the contraction at the nasal side of the field of vision becomes very plain; the optic disc shows a gradually increasing cupping, and the pulsation of the veins and that of the arteries is often seen; if it is not present, it can be easily produced by very slight pressure of the eye. In course of time the optic nerve becomes atrophic, the tension more marked, and the sight of the patient fails more or less rapidly, until the disease results in complete blindness.

Prognosis.—If a glaucomatous attack is very severe, it may destroy the sight of the patient in a few hours, *glaucoma fulminans*. But as a rule, a number of acute attacks are necessary to bring about this result. In the chronic variety it may take years, and in simple glaucoma, the process may last even longer, because the patient is not aware of the presence of the disease, and the physician is not likely to see the eye until it is nearly blind. If the disease has existed for some time, or if it has resulted in a deep excavation, or if the field of vision is much contracted, the prognosis is very unfavorable, and if a glaucomatous process is not interfered with, it will surely lead to complete blindness and degeneration of the eyeball. Inflammatory glaucoma that has resulted in total blindness, is called an *absolute glaucoma*. It presents a very characteristic appearance; it is of stony hardness, the pupil is dilated, the iris atrophied, and the cornea is hazy and anæsthetic, and the veins of the anterior portion of the eye-ball are prominently congested. This condition may not be altered; but frequently great degenerative changes of the eye take place. The iris atrophies; it is like a narrow band and the lens is apt to become opaque *glaucomatous cataract*; the vitreous humor becomes thin, and hemorrhages into the interior of the eye take place. The cornea becomes hazy, and the sclera may yield; which will lead to the formation of staphylomata. At times detachment of the retina takes place; this may be more or less complete, and ends in an atrophic condition of the eye-ball, (phthisis bulbi.)

Differential diagnosis.—Simple glaucoma resembles simple atrophy of the optic nerve, but the nature of the excavation, (see page 297), the fact that the nasal side of the field of vision is contracted, and a slight increase of tension of the eyeball, which is apt to be present at times, will render the diagnosis easy.

Chronic glaucoma might be mistaken for a beginning cataract, for neuritis or retinitis, and if the refractive media are not clear, and the tension of the eyeball not very marked, it may be difficult to make a correct diagnosis; but the limitation of the field of vision, the tension of the eyeball, and the condition of the ciliary vessels may be of help in this. If the media are clear and the fundus is visible, the diagnosis is easier. An intra-ocular tumor may be mistaken at times, for a chronic glaucoma, especially if it is accompanied by increase of tension, and if the interior of the eye cannot be seen; but such a condition is only exceptionally met with in intra-ocular tumors, which can, as a rule, be easily recognized by means of the ophthalmoscope; the pupillary space is not changed, nor are there remissions and exascerbations in cases of intra-ocular tumor. These growths may cause a defect of the nasal side of the field of vision, the same as we have it in glaucoma; but in the former case, the field will soon become greatly contracted as the tumor grows larger; in glaucoma the defect remains chiefly confined to the nasal side of the field.

Acute glaucomatous attacks may be mistaken for severe colds or for very violent cases of conjunctivitis; but the absence of a purulent discharge, the pain, loss of vision and the fact, that on eversion of the lids, the conjunctiva appears perfectly smooth, is not swollen nor granular in appearance, renders the diagnosis easy. From iritis it is differentiated by the fact, that the pupil is dilated and that no posterior synechiæ can be seen.

Treatment.—The treatment of glaucoma will rarely result in perfect recovery; but we may be able to relieve the acute symptoms of an attack and check the progress of the disease. The most reliable remedy to relieve the increased tension of the eye is an iridectomy. This was made first for glaucoma by V. Graefe 1857 and has been the means of saving a large number of eyes from total blindness; but it does not only preserve the sight, it is also the best remedy at our disposal for the relief of the intense pain. An iridectomy should therefore be made as early as possible and may be made during or after an attack. We will never be able to restore the sight completely by this operation if pathological changes of the optic nerve or retina have taken place, but the vision will generally be preserved in the state in which it was before the operation. An iridectomy made for a glaucomatous attack should be very broad and must include the most peripheral portion of the iris.

On account of the extreme shallowness of the anterior chamber, it may be difficult to make the corneal section without injuring the lens or iris, and the incision is best made with a very narrow cataract knife; for a description of the operation (see page 173). The iridectomy should be made directly upwards so that the upper lid will cover the most peripheral portion of the coloboma and prevent the dazzling effect of the new pupil, which is produced by the great amount of light that gets into the eye through such an opening. An iridectomy lessens the intra-ocular tension by diminishing the quantity of blood circulating in the eye. The arterial circle of the iris is destroyed, and a number of the capillaries of the iris are removed, and thus also the quantity of blood that circulates in the interior of the eye is reduced; but the operation will be also of great service in another way. The scleral wound made by the incision, and for an iridectomy for glaucoma the incision should always lie more in the sclera than in the cornea, heals by the formation of cicatricial tissue; this is not as dense and hard as the sclera and serves as a drain for the distended eyeball, because the process of filtration through it is easier than through the sclera and cornea. An iridectomy may be made in all stages of the disease except for glaucoma simplex, where there is but little or no sight left; but it or a neurotomy may have to be performed in perfectly blind eyes, affected with an absolute glaucoma, if such eyes are subject to acute attacks of pain. The sudden reduction of the tension may in some cases lead to intra-ocular hemorrages. *Glaucoma hemorrhagica.* This is a very dangerous condition of the eye and will generally lead to phthisis bulbi.

In order to avoid the unpleasant dazzling effect of the broad new pupil, the result of the iridectomy, a sclerotomy may be performed instead of it. This operation is a very simple one. The eye is to be brought under the influence of Eserine and as soon as the pupil is contracted, an incision is made into the upper portion of the eye at the sclero-corneal margin, in the same manner as has been described for a cataract extraction, but the section is not to be made all the way through the cornea; the knife is to be withdrawn before the cut is completed and a small upper portion of the cornea left intact. A bandage is applied and the patient is kept in the dark for a short time. This operation has the great advantage that it does not disfigure the eye and in chronic glaucoma, if the patient is particular about his appearance, it is preferable to an iridectomy; but if the attack is acute, an iridectomy should be performed, because it is more reliable. If the

CHAPTER XVII.

REFRACTION AND ACCOMMODATION.

THE true seat of vision lies in the optical centres of the brain, which are connected with the eyes by the optic nerves. The eyes are only the means of seeing; they receive impressions, the brain perceives them.

The eyeball may be divided into four portions; the function of the first one is to condense the rays of light emanating from an object and focus them on the retina; this is the dioptric apparatus of the eye. The function of the second portion is to receive these impressions; this is the retina. An image here formed is transmitted to the brain by means of the third portion, the optic nerve. The function of the fourth portion is to protect and support the more delicate portions of the visual apparatus.

The act of vision is therefore a very complex one, and depends upon a number of conditions that must be favorable for it. 1. In the first place it is necessary that light should be able to reach the deeper parts of the eye. Those portions of the eye through which the rays of light have to pass, must therefore be perfectly clear and transparent. Any opacity of these parts is apt to blur or interfere with vision. 2. The condensing apparatus, which is composed of a number of lenses, must be arranged in such a way that the rays of light are focussed upon the most sensitive portion of the retina. 3. This portion of the retina must be perfectly healthy; its function must not be disturbed. 4. That portion of the eye which transmits the impressions to the brain must not be interrupted or broken. The optic nerve must not be compressed or atrophied. 5. The optical centres must be in a fit condition to perceive the impressions carried to them by means of the optic nerve.

If any one of the last three links of the chain—the retina, the optic nerve or the optical centres of the brain, does not perform its duty, vision is impossible or imperfect; this condition is generally called amblyopia. If the refractive media are not perfectly clear, the image will also be blurred. If the different parts of the refractive apparatus are not arranged in such a way that the rays forming the image come to a focus on the macula lutea of the retina, vision will likewise be indistinct; this condition is caused by an anomaly of refraction. The diagnosis which of these three faulty conditions we have to deal with in a given case, is comparatively easy. In amblyopia clear and distinct vision is not attained with or without glasses, neither near by nor far away from the eye. Opacities of the different portions of the refractive apparatus of the eye are easily seen by a glance with the ophthalmoscope. If, however, distinct vision is obtained at some distance, either near or far, or if this is attained by means of glasses, amblyopia and opacities are easily excluded; such a case must be due to an anomaly of refraction or accommodation.

The formation of a clear, distinct, minute image of an object on the retina (*ocular vision*) depends upon the refractive power of certain parts of the eyeball. These parts are called the refractive media; they constitute the dioptric apparatus of the eye, which is composed of two lenses and two humors; they are the cornea, the aqueous humor, the lens and the vitreous humor, and of the auxiliaries, the iris and the ciliary muscle.

A. REFRACTION.

The faculty of the eye of bringing certain rays of light to a focus upon the retina without change of the natural conditions of the different parts, the eye being perfectly at rest, is called the state of refraction of an eye and depends on the form of the globe and its refractive media. If these parts are in such relation to each other and to the retina that parallel rays of light come to a focus on the macula lutea, that is, if the focal length of the dioptric apparatus and the length of the visual axis of the eye are alike, say about 23 mm. it is called a normal or *emmetropic eye*. (E). If the antero-posterior diameter of the eye is, however, shorter, less than 22 mm. or less than that of the normal eye, parallel rays are not focussed upon the retina, but at a point behind this membrane (see diagram). The image formed on the macula is therefore not defined, it is more or less blurred and indistinct. Such eyes are called *hypermetropic*, and this state of refraction is called *hypermetropia*. (H). If, on the other hand, the retina is farther behind the dioptric apparatus than in the normal eye, say more than 23 mm., which is the case if the antero-posterior diameter of the eye is greater in proportion than the rest of the eye, the focus of parallel rays is at a point anterior to the retina, and the image formed on the retina is again indistinct. This is contracted, and a slight increase of tension of the eyeball, which is apt to be present at times, will render the diagnosis easy.

Chronic glaucoma might be mistaken for a beginning cataract, for neuritis or retinitis, and if the refractive media are not clear, and the tension of the eyeball not very marked, it may be difficult to make a correct diagnosis; but the limitation of the field of vision, the tension of the eyeball, and the condition of the ciliary vessels may be of help in this. If the media are clear and the fundus is visible, the diagnosis is easier. An intra-ocular tumor may be mistaken at times, for a chronic glaucoma, especially if it is accompanied by increase of tension, and if the interior of the eye cannot be seen; but such a condition is only exceptionally met with in intra-ocular tumors, which can, as a rule, be easily recognized by means of the ophthalmoscope; the pupillary space is not changed, nor are there remissions and exacerbations in cases of intra-ocular tumor. These growths may cause a defect of the nasal side of the field of vision, the same as we have it in glaucoma; but in the former case, the field will soon become greatly contracted as the tumor grows larger; in glaucoma the defect remains chiefly confined to the nasal side of the field.

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On account of the extreme shallowness of the anterior chamber, it may be difficult to make the corneal section without injuring the lens or iris, and the incision is best made with a very narrow cataract knife; for a description of the operation (see page 173). The iridectomy should be made directly upwards so that the upper lid will cover the most peripheral portion of the coloboma and prevent the dazzling effect of the new pupil, which is produced by the great amount of light that gets into the eye through such an opening. An iridectomy lessens the intra-ocular tension by diminishing the quantity of blood circulating in the eye. The arterial circle of the iris is destroyed, and a number of the capillaries of the iris are removed, and thus also the quantity of blood that circulates in the interior of the eye is reduced; but the operation will be also of great service in another way. The scleral wound made by the incision, and for an iridectomy for glaucoma the incision should always lie more in the sclera than in the cornea, heals by the formation of cicatricial tissue; this is not as dense and hard as the sclera and serves as a drain for the distended eyeball, because the process of filtration through it is easier than through the sclera and cornea. An iridectomy may be made in all stages of the disease except for glaucoma simplex, where there is but little or no sight left; but it or a neurotomy may have to be performed in perfectly blind eyes, affected with an absolute glaucoma, if such eyes are subject to acute attacks of pain. The sudden reduction of the tension may in some cases lead to intra-ocular hemorrages. *Glaucoma hemorrhagica.* This is a very dangerous condition of the eye and will generally lead to phthisis bulbi.

In order to avoid the unpleasant dazzling effect of the broad new pupil, the result of the iridectomy, a sclerotomy may be performed instead of it. This operation is a very simple one. The eye is to be brought under the influence of Eserine and as soon as the pupil is contracted, an incision is made into the upper portion of the eye at the sclero-corneal margin, in the same manner as has been described for a cataract extraction, but the section is not to be made all the way through the cornea; the knife is to be withdrawn before the cut is completed and a small upper portion of the cornea left intact. A bandage is applied and the patient is kept in the dark for a short time. This operation has the great advantage that it does not disfigure the eye and in chronic glaucoma, if the patient is particular about his appearance, it is preferable to an iridectomy; but if the attack is acute, an iridectomy should be performed, because it is more reliable. If the object nearer to the eye or by the use of glasses, that have the power of making parallel rays divergent; these are concave, or as they are also called *minus* glasses. The strength of the glass required to make parallel rays of sufficient divergence, in order to be focussed on the retina of such an eye, expresses the degree of the patient's myopia. Thus the myopia may be equal to one dioptric of the new, or to $\frac{1}{36}$ of the old system.

In hypermetropic eyes the rays of light are focussed at a point posterior to the retina. In order to enable such persons to see distinctly, we must make the parallel rays of light convergent before they reach the eye, so that they can come to a focus on the macula lutea. This is accomplished by the use of convex glasses, and the strongest convex lens that enables the patient to see distinctly in the distance, expresses the degree of the patient's hypermetropia.

If neither concave or convex glasses improve the patient's vision considerably, and if there is no amblyopic affection or other disease of the eye, nor an opacity of the refractive media, the cause of the deficient vision lies most probably in an irregular curvature of either the lens or the cornea; this is called astigmatism, and in such cases the use of cylindrical glasses may be necessary to improve the patient's vision. This is found by testing him for astigmatism (page 346).

B. ACCOMMODATION.

We have so far considered the function of the dioptric apparatus of the eye adjusted for parallel rays, or the ability of the pensory ligament of the lens, in fact the ligament is attached to the muscle; whenever the muscle contracts, the ligament is drawn forwards; it becomes relaxed and the lens is enabled to resume a more globular shape and of course becomes of a higher refractive power, so that divergent rays are focussed on the retina. The nearer the object, the greater must be the curvature of the lens in order to focus the image upon the retina. This faculty of accommodation depends therefore partly on the action of the ciliary muscle and partly on the elasticity of the lens; if the ciliary muscle becomes paralyzed, no accommodation can take place; we have a paralysis of accommodation to deal with (see page 350). If, on the other hand, the lens loses its elasticity, which takes place when it becomes hard and unyielding in advanced age, the accommodation of the eye becomes more difficult and imperfect; this is called *presbyopia* (P) (see page 348). But even before any senile changes take place, the strength of the accommodative power may vary in different individuals and in different eyes. In young children the lens is almost as fluid as water; it has therefore the power to become very globular, and may become adjusted for very near objects; later in life the consistency of the lens becomes less fluid and the ability to see very near objects becomes more difficult; the near-point recedes from the eye farther and farther.

The near-point (*punctum proximum*) is the nearest point to the eye at which plain and distinct vision is possible. The far-point of the eye (*punctum remotum*) is the farthest point at which the finest print can be distinctly read. The distance between the far and the near point of an eye is the region of the accommodation. The power or the range of accommodation depends upon the change that the lens can undergo during the accommodative effort. This increase of the refractive power of the lens is equal to that of a lens, which, if it could be placed at the nodal point of the eye, would give the rays coming from the near-point (*p. p.*) the same direction as if they came from the far-point (*p. r.*)

The strength of this lens representing the power of accommodation is found by deducting from a lens of a focal length equal to the near-point that of one equal to the distance of the far-point. If for instance a patient can read fine print not nearer than four inches, nor farther than twenty inches, the strength of the accommodation would be expressed by $\frac{1}{4} - \frac{1}{20}$; which would be $= \frac{1}{5}$. or by a convex lens of a focus of five inches.

According to the length of the optic axis, the patient may require more or less accommodative power; if for instance the eye is myopic and has a larger antero-posterior diameter than the normal eye, so that parallel rays are focussed at a point in front of the retina, and the patient sees therefore parallel rays indistinctly, he will, if the rays are somewhat divergent, that is coming from a nearer object, see them distinctly without accommodation, because the optical axis being longer, they are now focussed on the retina, and only if the object is brought much nearer, so that the rays become very divergent, he must resort to the accommodative power of his eye in order to focus them properly. This will explain why a myopic eye has but very little to accommodate and in consequence of this, its muscle of accommodation, the ciliary muscle, is less developed than in other eyes; but it explains also why its far-point has to be much nearer than that of the emmetropic eye; the rays have to be divergent in order to form a distinct image on the retina. A hypermetropic eye, however, which has such a short optical axis, that even parallel rays are focussed at a point posterior to the retina when the eye is at rest, requires, in order to see distinctly in the distance, that the rays are made slightly convergent, which may be done by a convex glass. But a greater refractive power is obtained without glasses by efforts of accommodation, and this is what occurs in hypermetropic eyes for distant vision. If the object is, however, brought nearer than the far-point, the rays emanating from it will reach the eye in a divergent direction, and a much greater change in the convexity of the lens is required for near vision; this is accomplished by increased efforts of accommodation; such an eye requires greater accommodative power than an emmetropic one and much greater efforts than a myopic eye. The ciliary muscle is therefore much more developed than in non-hypermetropic eyes. The far-point of a hypermetropic eye must therefore be farther than that of the emmetropic eye.

For determining the far-point (p. r.) and the near-point (p. p.) we have to use very small test-types, the smallest that can be distinctly seen by the patient. For this purpose Snellen and also Jæger have devised test-letters on the same plan that has been described before. For testing for the far-point of an eye, the print has to be held as far from the eye, that the rays coming from such a distance reach the eye in a parallel direction. This is strictly speaking impossible, as all rays coming from an object, no matter how far off, strike the eye as divergent rays; but if they come for instance from an object twenty feet or farther away from the eye, they may be considered as parallel for all practical purposes. Such a distance is called the infinite distance and is expressed by the sign ∞. Any eye which sees the smallest test-types at twenty inches distinctly, has its far-point in infinity; this is expressed by the formula $\frac{1}{r} = \frac{1}{\infty}$.

The near-point (p. p.) is the shortest distance from the eye at which the smallest type can be read. It is determined by bringing the letters as near to the eye as they can be distinctly read; if this is at six inches from the eye in an emmetropic eye, which has its far-point at ∞, we say that its accommodation (A) is like $A = p - r$ or in this case $\frac{1}{A} = \frac{1}{6} - \frac{1}{\infty} = \frac{1}{6}$. This glass represents the increase of the curvature of the lens that has to take place in order to see rays coming from p, the near-point, which is in this case six inches from the eye, as if they came from an infinite distance; this is the range of the accommodation of the eye. In a hypermetropic eye we have to add to this lens the amount of its hypermetropia, and in myopic eyes we have to deduct from this the amount of the myopia.

Intimately associated with the act of accommodation is that of convergence of the eyes. The visual lines of both eyes are parallel if the accommodation is relaxed, and the eye is adjusted for the infinite distance; but if the eye accommodates for a distance of ten inches, there is also a convergence for this distance of ten inches; this relation is such an intimate one, that it takes place involuntarily; if we converge our eyes for a given distance, the accommodation will become at once adjusted for this distance, and on the other hand convergence will follow the act of accommodation. Convergence can, however, take place only to a certain extent, and the bin-ocular near-point is farther from the eye than the mon-ocular one. In regard to the former we speak of a *bin-ocular range of accommodation*, the latter indicates the *absolute range*. *Relative range* of accommodation is the range that is commanded while the convergence of the visual lines remains unaltered; it is therefore independent of the connection of the accommodation with the convergence.

We can test for the absolute range by examining each eye separately in regard to its near and far point; for the bin-ocular by testing both eyes together at the same time; for the relative by having the patient fix the finest test-types at a given distance, say in ten inches, and then find out the strongest convex and also the strongest concave glass that the type can be read with, without changing the distance of the test-types from the eye. In this manner the accommodation is changed without affecting the convergence. That part of the range of the relative accommodation, that is expressed by the convex glass, is called the negative part, whilst the concave glass represents the positive portion of the accommodation; that part that lies between the fixed point and the relative far-point is the negative part, it has been used up already; that portion that lies between the fixed point and the relative near-point is the positive part, it is still at our disposal. The proportion of the negative to the positive is not always alike, but to do near work comfortably, it should be like 2 to 3. If the patient accommodates for the bin-ocular near-point, the total accommodation is negative; if he looks at an infinite distance, the total relative accommodation is positive. This explains that a convex glass will blur the sight and that an emmetropic eye can see even through a concave glass distinctly, because the ciliary muscle cannot be relaxed any further, but that it is still able to do work and can overcome the diverging effect of a concave glass.

The anomalies of refraction are deviations from that of an emmetropic eye, and these are 1. Myopia, 2. Hypermetropia, 3. Astigmatism, 4. Anisometropia.

1. MYOPIA.

Myopia (M), nearsightedness, is due in the great majority of cases to an abnormally long eye. On account of this condition parallel rays of light do not come to a focus on the retina, which is too far behind the lenses of the dioptric apparatus. In very rare cases it may also be due to an unusually high refractive power of the lens or the cornea, caused by their greater curvature. As the focus lies in such eyes in front of the retina, distant objects are seen diffused and blurred, and in order to become distinct, the object has to be brought nearer to the eye, so that the rays become divergent before they reach the cornea; the far-point of the myopic eye is therefore not one at the infinite distance, but one nearer to the eye. Parallel rays coming from objects in the infinite distance, can however also be made divergent by means of concave lenses, and this is the reason why myopes can see distant objects through concave glasses better than without them.

Causes of Myopia.—Myopia seems to be a disease of civilization, and its prevalence in a nation may be looked upon as a proof that there are many hard students among them. It is not known among the barbaric tribes, and occurs but seldom among our negroes Myopia develops especially at the age of puberty, and is more frequent in men; it is principally acquired, and only in a small percentage of cases is it due to inheritance. The predisposing cause is perhaps in most cases a congenital tendency of the sclera to yield to any increase of pressure; this will often, by the slightest exciting cause, result in an elongation of the eyeball, and thus lead to myopia. But loss of resistancy of the sclera may also be due to greatly debilitating diseases, of childhood especially, and of these scarlatina and measles are perhaps the most frequent. It is therefore of great importance to keep children away from books or from school for some time after an attack of one of these diseases. But the most frequent cause of the affection is long continued school-life. This may be partly due to unfavorable surroundings; hence good light and ventilation of the school-room is of great importance. The light ought to be sufficient, and should not dazzle. If the light is insufficient, the scholar has to hold his book too close to the eye. If the ventilation is insufficient, the bad, heated atmosphere of the room is apt to favor congestion of the head, and also an increase of the circulation in the tunics of the eyeball. Another unfavorable condition in the schools is apt to be caused by badly arranged desks, necessitating a bad position of the scholar. But the most important of all these causes are the constant accommodative efforts required in such a mode of life, which are apt to result ultimately in changes of the shape of the eyeball. These efforts are always associated with convergence; the internal recti are constantly acting, and by their contraction, which has always to be counterbalanced to a certain degree by the opponents, the external recti, compression of the eyeball takes place, which under these circumstanees will eventually lead to an elongation of the optic axis. This is greatly favored by a fulness of the intra-ocular vessels, which may help to explain why in certain trades, where very close application of the eyes is necessary, but where no brain-work is required, only little myopia is met with; whilst brain-workers are apt to become myopic. A congestion of the intra-ocular vessels is also greatly favored by certain positions of the head; it is therefore a bad habit, which children have, to read or write with the head bent over, more than is necessary for good vision. This position interferes with the return circulation and leads to an increase of the vascularity of the fundus of the eye. In myopic eyes, that are not corrected by glasses, close application of the eyes, especially bending over when writing or reading, is necessary, and will often lead to a rapid increase of the near-sightedness. It is also injurious to study in insufficient light, or to write with a lead pencil; this necessitates likewise close vision, which is always associated with marked convergence and great muscular pressure on the eye. But there are still other causes of myopia, when for instance on account of some optical defect, maculæ corneæ or some forms of congenital cataract, objects have to be brought close up to the eye in order to be seen distinctly, thus necessitating great efforts of accommodation and convergence, which may eventually lead to an elongation of the eyeball: of course this can occur only in young individuals, especially children, because in old age the sclera becomes too resistant.

The immediate result of these conditions is either a compression of the globe by the action of the external muscles, or an increase of the intra-ocular pressure caused by the hyperæmic condition of the intra-ocular blood vessels, and also a constant traction of the outer portion of the optic disc during convergence. But not in all persons, that are subjected to these causes, will they result in myopia; a peculiar condition of the sclera must favor it. This is also the reason why myopia is apt to develop between the age of ten and thirteen; at this age harder study is required of the scholars than of younger ones and the sclera is not as hard and resisting as it is in later life.

The bulging of the sclera, which in marked cases of myopia is often found at the posterior portion of the eyeball, occupies the outer or temporal border of the optic papilla, where the sclera is without the protection of muscular tissue and of the tunica vaginalis. As the eye changes its shape and becomes more elliptical, the optic nerve comes to lie more at the nasal side, and the traction on its outer border becomes greater and a posterior staphyloma may develop rapidly (page 329).

The elongation of the optic axis corresponds to the degree of the myopia; in the beginning when the amount of the elongation is but slight, the degree of the myopia is likewise small, but in high degrees of myopia the length of the optic axis may be as much as thirty mm. or even more, that of the normal eye being only twenty-three mm.

Myopia is of frequent occurrence; especially the lower degrees of myopia are seen among the educated classes much more frequently than among the lower ones; but if it does occur among the latter, it is apt to depend upon a loss of resistancy of the sclera and is therefore likely to be of a high degree, and as these patients are not always anxious to have their near-sightedness corrected and to wear glasses, it is apt to be followed by serious changes of the eye and may often lead to complete blindness. This result is a very rare occurrence among those that have been constantly using proper glasses.

The degree of myopia is expressed by the glass that is needed to enable the patient to see objects clearly, which are at an infinite distance, and as said before, it is the number of the weakest glass the best vision is obtained with. These lenses will make the parallel rays divergent enough to be focussed on the retina. If this is accomplished by a — 12, we say that the patient has a myopia of $\frac{1}{12}$ or = 3. D. Another rough test for the degree of myopia depends upon the distance of the far-point of the eye. A person who can read fine print not farther than twelve inches from the eye, has probably a myopia of $\frac{1}{12}$.

The amount of vision that myopic patients have is generally good; myopic eyes of light or moderate degree have as a rule normal vision; but in highly myopic eyes we must expect to find some impairment of sight, even if there are no changes due to choroidal or retinal disease, which in this kind of eyes are so frequently seen and which would naturally cause great impairment of vision. In the absence of such affections the impairment of vision is due to scantiness of nerve-elements at a given point of the retina, caused by a stretching of this membrane, which follows the expansion of the eyeball. As the same amount of nerve-tissue has to cover a much larger area, it must necessarily be much thinner, and the retinal image has to be much larger than it was before in order to be appreciated by the same number of nerve-cells. Another obstacle to perfect vision is the size of the pupil, which is much larger than in the normal eye, and allows too large an amount of light to enter the eye, and diffusion of light may be the cause of indistinctness of vision. A myope in order to avoid this annoyance is obliged to partly close the eyelids, but this lessens again the clearness of the image. This peculiar habit, which is often seen in myopes that have a high degree of myopia but do not wear glasses, has given rise to the word myopia, which is of Greek origin. There is generally more or less frowning associated with this habit.

Myopic eyes have however advantages which other eyes do not have, and this is unusually sharp vision for fine objects near by; this is because at short distances the retinal image of objects is larger than in other eyes, and smaller objects may be distinctly seen, which other eyes can only see by means of a magnifying lens. Another advantage arises from the fact that the far-point of a myopic eye is nearer to the eye than that of other eyes; they require therefore but little or no accommodation at distances where other eyes have to accommodate strongly, and this enables myopes to do fine work much longer without feeling the slightest fatigue, than emmetropes and especially hypermetropes.

Symptoms and differential diagnosis of myopia. The most apparent symptom of myopia is the inability of such patients to see distant objects distinctly; they cannot read signs across the street that are easily seen by emmetropes, or cannot see the number of the houses and do not recognize features at a distance; in high degrees of myopia the patient cannot see distinctly at all unless the objects are brought close to his eyes. He lives in the world without seeing it. He is therefore apt to become reticent, he cannot enjoy or judge about things that other people see much better than he does and resorts therefore frequently to reading and leads the sedentary life of a student, which is again the most prolific cause of an increase of his trouble. The great effect of uncorrected errors of refraction on the development of the mind of such young persons cannot be too thoroughly appreciated by those in charge of young people, especially as the myopia is apt to be developed at a time when the young mind is easily influenced (Loring).

Differential diagnosis. Indistinct vision is however not only a symptom of myopia; we may have it in 1, opacities of the refractive media, especially of the cornea and lens; these latter are especially apt to be mistaken for near sightedness in young people, because such patients do not only have indistinct vision for the distance, but are also in the habit of bringing smaller objects close to the eye in order to be able to see them. The diagnosis in such cases is however easily made by means of the ophthalmoscope. Nor will such patients be able to read very fine print, no matter how near they hold it to the eye. 2. Indistinct vision of distant objects is also met with in amblyopic affections, that may be due to diseases of the deeper tissues of the eye, or it may be due to amblyopia, that is not accompanied with any visible lesions of these parts; but in these cases distinct vision is impossible either near or far, and fine print cannot be read at any distance, nor will there be any improvement by concave glasses. The ophthalmoscope will also in these cases be of great service; if the fundus can be distinctly seen by the direct method without the aid of concave glasses, there is probably no myopia, except perhaps of such slight degree that it would hardly affect the vision of the patient. 3. Hypermetropes, especially if their hypermetropia is manifest and of high degree, cannot see well in the distance; but this condition differs from myopia by the facts, that there is no improvement of sight by means of concave but on the contrary that they see better with convex glasses; hypermetropic eyes have deficient vision not only for far but also for near objects and often cannot read fine print without the aid of convex glasses, and by means of the direct examination with the ophthalmoscope we shall find that the fundus is readily seen without the aid of a lens and even through convex glasses.

Myopia may also be recognized by apparent changes of the eyeball. The elongation of the eyeball in the antero-posterior diameter will change the globular into an elliptical organ, whose diameter varies from 23 mm. of the normal eye, all the way up to 30 mm. and even more, and if the eye is rotated inwards, this change of the curvature of the eye becomes apparent; but in higher degrees of myopia the eyeball enlarges in all diameters; such eyes become very prominent, because the orbital tissues cannot be compressed to a great extent, and even slight degrees of exophthalmus, due to this enlargement of the eye, are seen in highly myopic eyes.

The change of the eyeball results also in changes of the more delicate structures of the interior of the eye, and especially the choroid is apt to suffer from the constant traction due to the expansion of the sclera. The choroid is firmly attached to the sclera at the entrance of the optic nerve, and as this lies to the inner side of the optical axis, the greatest traction of the choroid must be felt at the outer half of the optic disc, especially during the act of convergence. This results in great stretching of the tissue of the choroid, which, if seen by the ophthalmoscope, may look very thin and transparent, especially between the optic disc and the macula lutea. Eventually this will lead to atrophic changes, principally of the portion nearest to the disc and later to a slow inflammatory condition of the choroid, and thinning of the sclera itself at this point, which may become more or less bulging (*Posterior staphyloma, sclerotico-choroiditis posterior*, (page 247). The atrophy of the choroid becomes marked, and if in the beginning it appeared only as a white crescentic line at the outer half of the optic disc, it may later become very large and surround the optic nerve completely, forming an irregular white patch; but as a rule it occupies only the outer portion of the papilla and is more or less conical in shape, with the rounded base toward the optic disc and the apex of the cone extending toward the region of the macula. The higher the myopia, the more developed the crescent or cone is apt to be, as a rule, but there are many exceptions.

As there is but a slight difference in the appearance of the disc and this atrophic patch, the shape of the papilla appears altered, elliptical, with the longest diameter in the direction of the crescent.

The inflammatory process of the choroid may, however, if the myopia increases, extend to the rest of that membrane and great changes may take place in it, resulting in a number of atrophic patches. The vitreous body is apt to suffer likewise; dense vitreous opacities will in these cases obscure the sight of the patient, and the vitreous itself becomes greatly changed in consistency, it becomes very liquid (*synchisis*). In less severe cases the vitreous opacities may be very fine and diffused, causing hardly any impairment of sight, but give rise to the very annoying symptom, called muscæ volitantes, which myopic patients complain about frequently; or the opacities may be very slight and appear as one or few dark specks floating before the sight of the patient.

The retina, being more or less stretched in highly myopic eyes, is but loosely adherent to the choroid; this and the fact, that on account of the changes of the vitreous body, it loses its support, predisposes it to become detached from the choroid by serous effusions, if the slightest exciting cause occurs. Disturbances of the nutrition of the lens lead in cases of high degree of myopia at times to opacities of it. These cataracts begin, as a rule, as posterior polar cataracts; but they become soon complete and are found later with other great degenerative changes of the eye, such as irido-choroiditis; even calcareous degeneration of the lens may take place.

These changes are apt to develop after the slightest injuries and especially after great strains of accommodation, caused by reading and working late at night, or by the use of too strong glasses, or after a change of those that the patient had become accustomed to for stronger ones. But they are also noticed without apparent cause, and especially in such cases where the sclera seems to lack resistancy, the process will gradually increase until the patient is nearly blind.

The symptoms accompanying these conditions may be very insignificant; but there is generally great sensitiveness to light, so that the patients prefer not to go out during the day, but keep in a dark room, which is however very injurious as it lowers their power of resistance. Great pain is but seldom complained of; it is more a heavy dull sensation of the eyes that is spoken of by such patients; but the pain may be very intense, especially after using the eyes considerably.

Another complication of myopia is insufficiency of one or both internal recti muscles. This is the result of the increased difficulty of convergence; the eyeball is no longer a globular body rotating easily in all directions, it is more or less elliptical, and especially the act of convergence is difficult. As these patients have to hold everything very close to their eyes, the internal recti are constantly called upon to act; they become easily tired, especially after long-continued accommodative efforts, accompanied by convergence; they fail to fulfil their function. One of them is apt to give out first, because it cannot rotate the eye as powerfully as the other one, and slight diplopia manifests itself. The patient, when reading, sees two pages instead of one and the single letters seem to run into another and become indistinct; the muscles begin to ache, and the pain may extend to the brow; this is called *muscular asthenopia*. Very soon it is impossible to continue bin-ocular vision on account of the impaired convergence, and the patient has to give up work for some time or the vision has to become mon-ocular, when the necessity of convergence is done away with. The internus that began to give out first will become weaker, and the opponent, the rectus externus, may gain a preponderance over it and the eye will be drawn outwards; its visual axis will deviate more and more resulting eventually in *divergent squint*. This is frequently seen in myopia where the sight of one eye is much weaker than that of the other. It may show in the beginning only if the eye is adjusted for the near-point, but eventually it will become permanent, (see page 68.)

Sometimes in the beginning of myopia, when the eye is not yet accustomed to the myopic conditions, spasmodic contractions of the ciliary muscle may take place (*spasm of the accommodation*); the objects are held closer to the eyes than is necessary, and this becomes now another cause of rapid increase of the myopia. Myopic eyes have generally a wide pupil and a deep anterior chamber.

One of the most reliable means of diagnosis of myopia however is the ophthalmoscope.

1. In the direct examination the fundus of a myopic eye may be seen at some distance from the eye; it is however magnified to such an extent that only a small portion of the fundus is visible at a time, and the image is an inverted one. This is shown

by the fact that when the observer, while looking at the vessels of the fundus, moves his head a little from one side to the other, the image is seen to move in an opposite direction. If for instance the observer moves his head toward the temporal side of the observed eye, the blood-vessels are seen to move toward the nasal side. According to the degree of the myopia the details of the fundus can be seen nearer or farther away from the eye. In the higher degrees they may be seen within ten inches of the eye; in the lower degrees, this point may be forty or fifty inches away from the eye, and it is difficult to recognize them under these circumstances.

2. If the observer approaches in the direct examination close to the eye, the fundus cannot be seen distinctly; it looks blurred and in the higher degrees of myopia only the red reflex is seen. This is of great importance, because the details of the fundus cannot be seen even by accommodative efforts, the most frequent mistake made by beginners in the use of the ophthalmoscope, and myopia is therefore easily diagnosticated even by non-experts. But the fundus becomes at once more distinct if a concave lens is moved behind the mirror of the ophthalmoscope and becomes very plain and perfectly distinct if the glass, equal to the myopia of the eye, or even a stronger concave lens, is used. The weakest concave glass that the fundus of the observed eye is plainly seen with, all accommodation on the part of the patient and observer being relaxed, represents the degree of the myopia of the eye.

3. Resorting now to the indirect method, we find at the very beginning that the fundus can be distinctly seen without removing the head very far from the eye to be examined, and in high degrees of myopia we are able to see the ærial image, formed by the lens, which is held in front of the patients eye, within ten or twelve inches, or even nearer; but we find also that the parts of the fundus appear smaller than usual and the optic papilla has for instance a very short diameter. Again we see that if the lens in front of the eye is held further away from it, that the disc appears to increase in size and becomes smaller again, if the lens is now moved nearer to the eye.

The ophthalmoscopic appearance of the fundus of a highly myopic eye varies considerably according to the changes of the choroid, that have been caused by the myopic condition of the bulb. There is hardly any change whatever to be seen in milder cases, but as soon as the myopia increases, the crescent is apt to become distinctly seen; it will usually increase with the degree of the myopia, and may assume various shapes. The choroid and retina may appear thin and changed.

Prognosis: A near-sighted eye is usually considered a very strong eye by the general public, because myopes can work a long time without fatiguing their eyes; but this impression is an erroneous one, for myopic eyes are always more liable to suffer from injuries or diseases than other eyes. This is perhaps hardly perceptible in lighter cases, but in myopia of high degree the slightest injury, a slight blow or a fall, may result in detachment of the retina or even lead to the formation of a cataract. Exertions of the eye that may tire an emmetropic or hypermetropic eye, without leading to any morbid changes, may be followed in highly myopic eyes by choroïditis and vitreous opacities.

Of the greatest importance is to determine whether the myopia of an eye is progressive or stationary. As a rule, myopia may be considered stationary, if it has not increased to any extent after the twentieth year, and is of slight or moderate amount, say $\frac{1}{12}$ or less. In these cases we have no or only a slight posterior staphyloma, and there is no tendency to an increase of the myopia, because the sclera has become so hard and resistant at this age, that it will yield only in exceptional cases. Myopia that progresses slowly is generally not called progressive; this term is reserved for those cases where the increase is rapid and accompanied by slight congestive symptoms, such as local heat, dryness and a dull, heavy sensation of the eye, sensitiveness to light and even pain; photopsies and mouches volantes are also mentioned as annoying symptoms by such patients.

Myopia may be progressive only for a short space of time; this occurs generally between the twelfth and twenty-fifth year; after this it is more apt to remain stationary; but a more dangerous variety is the constantly progressive myopia; it depends upon a want of resistancy of the sclera and is apt to develop during puberty and will increase steadily or in jumps, until the eye has lost most of its visual power; in many instances it will terminate in detachment of the retina or in cataract.

Treatment. — Myopia, if once fairly established, cannot be cured; it is principally due to a change of the eyeball and this cannot be remedied. Cases of apparent myopia, which are due to spasms of accommodation, may be cured by the use of atropia and rest of the eye; but cases of real myopia can only be benefited by glasses. We should therefore be careful to impress parents or teachers with the necessity of preventing myopia, if possible. This is to be done by strict attention to the method of studying which the children have, to the amount and quality of the light they work by, and the arrangement of the desks; these ought to be inclined and of such a height that it is not necessary to bend over while working. The light ought to be as good as possible, daylight should fall over the patient's left shoulder, and artificial light should be bright and steady; it is on this account that the common student's lamp gives perhaps the best light to study by. It is not good to continue too steadily at one object; the eye should be rested at times, and if possible the child should be allowed to get up and walk a little around the room at short intervals; the print of the book should be large and distinct, and on good paper, and a great deal of out-door exercise should be insisted on. Habitual constipation even may favor the development of myopia.

Another question of great importance is what glasses are we to select for our patient, and when ought he to wear them? There is a great prejudice against the use of glasses, especially among the lower classes; it seems to these a disgrace to wear them, and they imagine that it will ultimately do harm to the eyes, so that they "cannot do without them after once using spectacles." This is, however, entirely wrong, and the timely use of glasses might have saved many an eye from total blindness.

The glasses required in these cases are concave lenses, and it may not only be necessary to give them for distant vision; but some myopes require also glasses for near-work, such as reading and writing. The rule in myopia is to give always the weakest glass the patient has the best vision with. If the myopia is, however, of a moderate degree, if it is less than $\frac{1}{6}$, we may give our patient spectacles that he may use for near as well as for distant vision. Such glasses ought to be worn all the time and become as a part of the eye. In the selection of such glasses it is especially necessary (1) to take the weakest ones the patient has the best vision with. If, for instance, our patient sees the bottom line of Snellen's test types at 20 feet, with a -10, a -8, or a -7, we should give him a -10 for both eyes, provided they are alike. (2.) Myopes, if they get glasses which are to be kept on all the time, must learn to accommodate more than they did before. It is therefore of great advantage to begin with the use of them early in life, so that the eye gets accustomed to the increase of the accommodation. In old people we should be very careful not to give too strong a glass, because it is dangerous to task their accommodation too much by such a change, as it might lead to exudations and even to hemorrhages into the vitreous body, and to an increase of the myopia. (3.) If the myopia is of moderate amount, say $\frac{1}{16}$ or $\frac{1}{12}$, glasses should only be used for distant vision, near-sight being good enough; they may be ordered in the shape of eye-glasses.

(4.) In myopia of high degree it is not advisable to correct the whole of the myopia, because the strong concave lenses will produce a very small image on the retina; nor must such glasses be worn all the time, because they tax the accommodation too much.

If the far-point lies too near to the eye for comfortable vision, it should be removed, by means of concave glasses, to such a distance as will not necessitate much convergence. In order to find the proper glass for this purpose, we have to deduct from the total amount of myopia the amount of a lens whose focal length corresponds to the distance that the patient wants to see in. If, for instance, the patient has a myopia of $\frac{1}{4}$, his far-point is at four inches, and everything that he wants to see distinctly has to be brought within this distance. In order to remove his far-point up to sixteen inches, for instance, we have to deduct $\frac{1}{16}$ from $\frac{1}{4}$, which will leave $\frac{3}{16}$ or $\frac{1}{5}$. This is the glass the patient has to use for a distance of about sixteen inches. If the patient desires to read music distinctly at 32 inches, we have to deduct $\frac{1}{32}$ from $\frac{1}{4}$, this will leave a $4\frac{1}{2}$ concave glass. A -5 would in such a case make the rays coming from sixteen inches as divergent as if they came from a distance of five inches.

The object of giving myopes glasses for near objects is to remove their far-point from the eye, so that they can do fine work without great effort to converge, which might lead to weakness of the internal recti muscles and to asthenopic troubles, and would of itself be a cause of the increase of the myopia. If the weakness of the internal recti is already very troublesome, we must not only give them concave glasses, but combine with these glasses prisms of a moderate strength (see insufficiency, page 66) and let the patient use these glasses for near work. (5.) If the myopia is only of a moderate degree it will probably not interfere with the work the patient is doing, but there may be distressing asthenopia on account of the weakness of the interni; in such cases we may advise the use of prisms without combining them with concave glasses. In exceptional cases, where these means fail to give relief, it may be necessary to divide the external rectus of one or both eyes; this should, however, be done very carefully as it might lead to convergence and very annoying diplopia.

It does not require such care if there is marked divergent squint of one eye already.

(6.) If the myopia is progressive, or is during its course accompanied by congestions, or spasms of the ciliary muscle, which produce pain, photopsies and sensitiveness to light, the application of leeches and especially of the artificial leech, will be of great service; such patients ought to be put under the influence of atropia for several weeks and kept in a dark room. This will relieve the patient considerably and check the progress of the myopia for a time, because it does away with all efforts of accommodation and convergence and gives the eye perfect rest.

(7.) As the myope advances in age, his myopia, if it is only slight or of moderate degree, may enable him to work without glasses when other persons with normal eyes have to use convex ones, because through the decrease of power of the lens, the rays will be focussed easily on the retina; but if the myopia is of high degree, the vision will be poor for near as well as for far objects, and in such cases different glasses are needed; they may be a strong concave glass for the distance and a weak concave, and in some cases even a weak convex glass for near objects. These two glasses may be combined in one frame, in such a way that the upper half of the spectacles contains the glass for the distance, while the lower section is used for vision near by. Such glasses are called Franklin glasses, Benjamin Franklin, who was near-sighted himself, having invented them. They are of great value to business men and teachers. Similar convex glasses are made for hypermetropes, when they become presbyopic.

To recapitulate, persons having a myopia of more than one fifteenth or two and a half D, should begin to wear glasses when young. These glasses should be worn all day and become a part of the eye; they may be worn in the shape of eye-glasses or spectacles, but should be made in such a way that the centre of the glass lies exactly opposite the pupillary spaces, and should rather be weaker than stronger than the degree of the myopia would indicate. The greatest care is necessary for the treatment of marked progressive myopia.

Myopes should only read, write, or do any kind of fine work by a steady and good light, and if possible should use only books with large type and good paper. The object of this is to enable them to do their work without bringing the objects looked at too close to the eyes and avoid therefore all great efforts of convergence and accommodation. An erect position, especially when at work, is greatly desired, and if the myopia is very marked the patients should have glasses strong enough to prevent them from bending the head over too much.

Myopes, while studying or doing any fine work, should not remain longer than ten minutes in the same position. They should frequently get up and take a long breath, which will facilitate the return of the venous blood and prevent congestion of the head and the more delicate parts of the eye; nor should they face the light, but this should come over their left shoulder. When working by artificial light, the eyes should be protected by a shade, either over the flame or over the eyes, so that only the object looked at is seen and the dazzling and irritating effect of the flame is avoided.

HYPERMETROPIA, H.

It has been said that the normal (emmetropic) eye is the exception. We have seen that myopia is of frequent occurrence but hypermetropia is even much more frequently met with.

Hypermetropia, far-sightedness, or better over-sightedness, depends on an abnormally short optic axis, which is a congenital condition, it having been observed in infants (Ely). Parallel rays are brought to a focus at a point posterior to the retina if the optic axis is abnormally short, and as these rays have not yet come to a focus when they reach the retina of such an eye, they cannot produce a distinct image. Hypermetropes have therefore deficient vision, and no change of the distance of the object from the eye will cause the rays emanating from it to come to a focus on the retina; on the contrary the nearer an object is brought, the more divergent are the rays reaching the eye and the further back will be the focal point.

In order to focus these rays properly, the dioptric apparatus must increase its refractive power, or the rays must be made convergent before they reach the eye, and this is done by the aid of a convex lens. The nearer the object is moved to the eye, the greater must be the change of the lens of the eye or the more powerful must be the glass that is used to converge the rays before they reach the eye. This is the reason why the vision of hypermetropes is improved by the aid of convex glasses.

If the degree of the hypermetropia is not great, that is, if the optic axis is only a little shorter than that of an emmetropic eye, the increase of the refractive power of the eye is easily accomplished by accommodative efforts, producing a greater refractive power of the lens, which is changed to a more convex and in marked cases to an almost globular body. The action of the ciliary muscle may frequently suffice to overcome the defect in the eye, without that the patient is even aware of its action or becomes cognizant of the optical defect and may be enabled to see well in the distance and near by and have perfect vision for the distance; in fact the hypermetropia does not become manifest. But if the hypermetropia is more pronounced, the eyeball being much shorter than in the normal eye, accommodative efforts may not be able to overcome the defect, or this may require such efforts that the power of the ciliary muscle is soon exhausted, which is very apt to be the case after severe debilitating diseases, when all the muscles become weak. Such patients do not see distinctly in the distance nor near by; the image of objects is blurred, and they cannot read fine print even by holding it close to the eyes; this is *manifest hypermetropia*. Or if they can see objects distinctly for a time, these will become blurred and indistinct as soon as the ciliary muscle becomes fatigued.

In other cases the hypermetropia is easily overcome by accommodative efforts as long as the lens remains soft and yielding, but if, on account of the patient's age, the lens becomes harder and accommodation more difficult, which is often the case at the age of twenty or thirty, accommodative efforts will not be sufficient, and hence the hypermetropia manifests itself, especially after reading or writing for a long time, the accommodative power of the eye being taxed to a great extent. The difficulty is increased by insufficient or artificial illumination, and is therefore apt to manifest itself in the evening. The eye becomes easily tired and sleepy, and objects looked at, letters for instance, become indistinct. The patient is obliged to close his eyes for a short time. This will rest the ciliary muscle somewhat, and it will act as usual, but it becomes now tired in less time than before, and soon the unpleasant symptoms spoken of manifest themselves again. As they depend on a weakness of the accommodative power of the eye, the condition is known as *accommodative asthenopia*. If the patient continues to work in spite of these slighter manifestations of asthenopia, they will be followed by congestion of the blood-vessels of the lids and conjunctiva; the lids feel heavy and hot, and the enlarged conjunctival vessels will produce a gritty sensation, as if grains of sand had got into the eye; the conjunctiva feels dry and rough and the upper lid seems to be glued to the eyeball; later lachrymation and pain in the ciliary muscle will make a continuance of work almost impossible; the pain may become reflex and is generally described as affecting the forehead, but it may extend all over the head and result in dizziness and may often be mistaken for some nervous disorder, especially as the distant vision of the patient may remain perfectly good, so that he is hardly aware of any optical defect.

Accommodative asthenopia is greatly increased by and is sometimes entirely due to debilitating influences of constitutional affections; hence it is often seen after severe diseases. It is apt to follow long-continued study, especially if the general tone of the system has been reduced by a change in the manner of living; it is therefore apt to show itself during the latter part of a course of studies, or before examinations, which require a great deal of hard study. It will in these cases disappear after some time when the health has been restored to the normal condition and if close application, especially night work, is no longer required. Persons that had to use glasses during such periods may be able to do without them after some time; especially if they begin to practice medicine and have time to rest their eyes.

According to the degree of the hypermetropia and the accommodative power of the eye, this optical defect may manifest itself differently, and we call the hypermetropia, if it does not show itself at all, that is, if the power of accommodation is so great that it overcomes the deficiency in the optic axis for near and far objects, with or also *without* weak convex glasses, *facultative hypermetropia.*

If the patient's vision is not perfect, because the accommodative effort is not equal to the amount of the extra work, the hypermetropia becomes manifest, and the patient will see better with convex glasses than without them; this is *manifest hypermetropia.*

If the accommodation be paralyzed, the total amount of the hypermetropia becomes manifest, and the true condition of the refraction is easily recognized; this is called *total hypermetropia.* That amount of it that was concealed by accommodation becomes now apparent through the difference between the manifest and total hypermetropia, and is called the *latent hypermetropia;* the amount of the latter differs according to the strength of the accommodation; if this is very powerful as in facultative H, the total amount of H is latent; if the accommodation, however, is weak, or if it is made impossible, because the lens cannot change its shape, for instance in old people, there may be no latent H at all, because the total amount of it is now manifest.

Relative H we call that condition in which the patient can accommodate for parallel and for divergent rays, that is, for near as well as for far objects, but only by using greater accommodation than would be necessary for that distance. This is associated with greater convergence and produces periodic squint; the patient sees therefore only with one eye. *Absolute* is the hypermetropia called when neither near nor far objects are distinctly seen without glasses.

The total amount of the hypermetropia of an eye can therefore only be made out after the use of atropia, which paralyzes the accommodation; it is expressed by the strongest convex glass by which the best vision for distant objects is obtained. If a patient sees, for instance, the bottom line of Snellen's test-types with the aid of a + 12 and also with a + 10, but not distinctly with a + 8, we say his hypermetropia is $\frac{1}{10}$, because a + 10 is the strongest glass that gives him acute vision. The strongest convex glass that he can see with distinctly in the distance, without his accommodation having been paralyzed by means of atropia, represents the amount of his manifest hypermetropia. The patient may, for instance, see the last line of the test-types without glasses, but not quite distinctly, and can see it fully as well, perhaps a little better, with a + 60, but also with a + 48, in which case his manifest hypermetropia is $\frac{1}{48}$.

With the gradual change in the lens, the amount of manifest hypermetropia increases, whilst the latent hypermetropia decreases. Hypermetropes will have to resort to the use of convex glasses as soon as the slightest amount of presbyopia manifests itself; this is earlier in life than is the case in emmetropic and especially in myopic eyes.

The acuity of vision is as a rule perfect in eyes having a slight or moderate amount of hypermetropia, but in very marked cases, where the use of very strong glasses is required, the acuity of vision is often somewhat impaired, which may be partly due to the spherical aberration of the strong lenses.

The near-point of a hypermetropic eye is farther from the eye than in E or M, and the far-point is practically farther than ∞, but it is negative and the range of the accommodation may be even greater than in emmetropic eyes; the ciliary muscle is usually greatly developed. The length of the optic axis does not vary as much as in myopic eyes, it is generally between 17 and 22 mm.

The ophthalmoscopic diagnosis of a hypermetropic condition is more difficult than that of myopia. 1. In the direct method the fundus may be seen as well or even better through a concave glass than through a convex lens, and is also seen without glass, on account of the accommodation being at work even when the patient looks at distant objects, but the fundus *can* be seen through a convex glass; it requires, however, some skill to determine the degree of the total hypermetropia in this manner. It corresponds to the strength of the strongest convex lens that we can see the fundus distinctly with, when we bring our eye close to that to be examined and relax our accommodation entirely. The only reliable method is to bring the eye completely under the influence of atropine, and even the observer, if he is not able to relax his accommodation entirely, should have his eye brought under the influence of a mydriatic. 2. In the direct method the fundus can be observed at some distance from the eye. The image seen is not an inverted one as in myopia, and the details of it are seen to move in the same direction of the observer's head, if this is moved from side to side. 3. By the indirect method the disc and retinal vessels appear larger than in the normal eye, and 4, in order to see the fundus distinctly, the head of the observer has to be held quite a distance away from the eye, or a weak convex glass has to be used behind the mirror of the ophthalmoscope in order to make the rays more convergent; if, for instance, a + 24 is moved behind the perforation of the mirror, the fundus may be seen at a distance of twelve or fifteen inches, and can therefore be examined more conveniently as if the ophtholmoscope would have to be held thirty or thirty-six inches away from the eye.

The necessity of great accommodative efforts in hypermetropia does not only result in asthenopic trouble, but leads often to affections of the internal recti muscles. All accommodative efforts are intimately associated with convergence, and this may result early in an abnormal development of the internal recti, especially in relative hypermetropia; or if there is an unequal degree of H in the two eyes, one of the recti interni will contract more than the other, and this will result in a deviation of the optic axis; convergent squint is apt to develop in this way. In the beginning the squint, which is a concomitant one, may be temporary, but it will soon become permanent. It is apt to develop early in life, as soon as the child begins to see attentively. Insufficiency of the externi is apt to be present in such cases and this favors the development of strabismus. It is especially in hypermetropia of a moderate amount, that we notice the appearance of squint, because [illegible]ees of H even strong accommodative efforts do not give clear vision and are but seldom resorted to.

Hypermetropia is congenital; sometimes, however, it is acquired, and we have seen before, that it is of frequent occurrence; it depends in marked cases upon a defective development of the eyeball. Such an eye is generally deeply set, and has a narrow anterior chamber and a contracted pupil. The shape of the eyeball may be seen by rotating it inward, but only in marked cases is this greatly changed. Acquired hypermetropia is comparatively rare; it occurs after removal of the lens, either by extraction or by accidents, and it occurs also in old age when the lens becomes flatter: or it may be the result of morbid processes, which produce changes of the cornea or lens.

The prognosis of hypermetropia is much more favorable than of myopia, because there is no tendency of the hypermetropia to increase, nor is it apt to lead to great changes of the interior of the eye; it is true that glaucoma is apt to be developed in hypermetropic more than in other eyes; but this is of rare occurrence when the immense number of hypermetropic eyes is taken into consideration. In the course of time a hypermetropic eye may become emmetropic and even myopic by causes that we have considered before as being capable of leading to an increase of the length of the optic axis of an eye. The greatest danger in hypermetropia is the development of squint, which may lead by non-use to very defective vision of one eye.

Treatment of hypermetropia.—This is more difficult and unsatisfactory than would appear at a first glance. We cannot always give the glass that will correct the hypermetropia and let our patient use this all the time, because he is not always able to do away with his abnormally strong accommodation. In milder cases of hypermetropia the patient may be able to do any amount of work, except if his power of accommodation should be weakened by disease, and in this case tonics may be as necessary as glasses; and if the accommodation is reduced from overwork, we should especially order rest of the eyes. But we may have to do more than this, and, especially if the hypermetropia is of a higher degree and a large portion of it becomes manifest, convex glasses must be prescribed.

The lens to be given to a hypermetropic patient depends on his age as well as on the degree of the H. Should we attempt to give a patient of twenty-five or thirty years of age a glass that corresponds to the total H, we shall find that he is not able to use this glass for any length of time without feeling pain and complaining about other unpleasant symptoms. It is necessary to give a weaker glass that will aid his accommodation. In fact, to remove the cause of excessive use of accommodation and convergence must be the main object of our treatment. In children this is somewhat different; their eyes will get used to the glass; their accommodation adapts itself to it. We may give them spectacles that correct the whole amount of their H t, and let them use these glasses all the time. In middle-aged persons the best plan is to correct their manifest H by the strongest glass they can see well with in the distance. This will be followed by great relief of the asthenopic symptoms. But we shall find that in many cases the amount of manifest H increases quite rapidly, and we may be called upon to give stronger glasses every few months, until the total H is corrected. But if the glasses, that we use to correct the manifest H with, should prove too strong, which is shown by pain and a sensation of straining after using the glasses for a few minutes, we must give weaker ones in such cases.

Prophylactic treatment of H is especially necessary in very young children with higher degrees of H, because this is apt to lead to strabismus. Such patients should not be allowed to play with very small objects, nor should they go to school too soon. If any signs of squint manifest themselves the eyes should be tested for the total H, each eye separately and under the influence of atropine. Such children should wear their glasses constantly. This may prevent and even cure slight cases of strabismus. If we find that a hypermetrope, when using convex glasses, has to bring the objects very near to his eyes in order to see and complains about pains after using them, we must give weaker ones; but if they are not relieved of the asthenopic symptoms by these glasses, we must give stronger ones. No definite rules can be laid down for these cases.

Hypermetropia, when not corrected, may frequently be associated with blepharadenitis and conjunctival troubles. These will, as a rule, disappear after the use of proper glasses, but we may have to order also a mild astringent collyrium, such as: ℞ Acidi boracici, gr. xviii; aquæ camphor, ℥iij; mucil. cydonior, ℥i. M. This will give great relief in such cases, and should be combined with the use of a very mild ointment of red precipitate, to be applied before going to bed, in case blepharadenitis should be found to complicate this condition. The following eye lotion: ℞. Aluminis, grs. x; aquæ camphoræ, ℥ij, will be of great service in conjunctival complications.

ASTIGMATISM.

There are eyes in which parallel rays passing through the cornea cannot be focussed exactly on the retina, even if the optic axis is of the normal length, on account of a lack of symmetry of a portion of the dioptric apparatus. In these cases the state of refraction differs in the various meridians of the eye, which have a different degree of curvature. This must result in an imperfect focussing of the rays on the retina, and cause the formation of a blurred, indistinct image, which is, of course, the same whether an object is far off or near by. If, for instance, the focal length of the cornea in the horizontal meridian is normal, say 31 mm., that of the vertical meridian, however much shorter, for instance 27 mm., the image formed by such a cornea must be distorted, and the flame of a candle will appear elongated in one direction, because the rays reaching the retina from one, say the horizontal meridian, may be focussed exactly on it, but those coming from the vertical meridian have come to a focus before reaching the retina and cause diffusion of the image.

The distance between the two focal points of such an eye is called the focal interval and represents the degree of the astigmatism. We may have a number of anomalies of curvatures of the refractive media to deal with, and accordingly have a number of varieties of astigmatism. If the principal meridians present uniform segments of a circle, the astigmatism is called regular; but if the curvature is more or less irregular, there is an irregular astigmatism present.

The most frequent anomalies of curvature, causing astigmatism, are found in the cornea; especially regular astigmatism is nearly always due to differences of the various sections of the cornea. In irregular astigmatism the changes may be in the cornea, and may be congenital or are the result of ulcerations of the cornea, or it is due to changes in the curvature of the crystalline lens, or it may be due to displacement of the lens, as we see it in dislocations. In these conditions we have also frequently monocular polyopia and metamorphopsia. This kind of astigmatism cannot be corrected by glasses, but it may sometimes be benefited by plain concave or convex lenses.

Regular astigmatism is generally congenital and may be hereditary; in it the two principal meridians, that of the greatest and that of the least refractive power, are always at right angles to each other, that having the highest refractive power is generally the vertical one. If in one of the principal meridians the retina is at the right focal distance of the refractive apparatus, the eye must be emmetropic in this meridian and ametropic in the other. If this is the case the astigmatism is called *simple*, and according to the refraction of the ametropic meridian we have *hypermetropic astigmatism*, if the focal point of this meridian is longer than that of the normal, and comes to a focus at a point behind the retina; this requires the use of a convex cylindrical glass to correct it. If the other meridian is, however, of shorter focus than that of the normal meridian, the rays will come to a focus in front of the retina, this requires a concave cylinder to correct the deficiency; it is called simple *myopic astigmatism*.

Compound astigmatism is that variety in which both meridians are ametropic; either both are myopic, one, however, more so than the other; this is compound myopic astigmatism; or both are hypermetropic, and this is known as compound hypermetropic astigmatism. These anomalies are corrected by a concave spherical combined with a concave cylindrical glass in myopic conditions, or by plain convex and convex cylindrical glasses in hypermetropic astigmatism. *Mixed astigmatism* is that variety in which the one meridian is hypermetropic and the other myopic, and this variety is corrected by a combination of a concave and a convex cylindrical glass, which generally have to be arranged so as to be at right angles to each other. This latter variety is the most difficult one to correct.

Symptoms and means of diagnosis. — Impaired or indistinct vision is perhaps the most apparent of the symptoms. If such patients are tested with glasses, it is found that the vision can be but little improved by the use of spherical ones. They do not see well near by nor far off, if the astigmatism is of a high degree, but in slighter cases, where the difference between the ametropic and normal meridian is equal to $\frac{1}{40}$ only, it is easily overcome by accommodative efforts; the ciliary muscle will adapt itself to the requirements of each meridian. The astigmatism is also less marked when the pupil is narrow than when this is wide. Such patients see therefore much better on clear than on cloudy days, and require brilliant light to see by. These unequal efforts of the different parts of the ciliary muscle are very apt to result in marked asthenopic conditions. Conjunctival irritation as well as blepharadenitis is often met with in these cases. Astigmatism is frequently associated with myopia, and especially in high degrees of M. there is frequently some astigmatism, the additional correction of which will be highly appreciated by myopes, especially if they have used only spherical concave glasses before.

The nature of the anomaly of curvature is sometimes very difficult to diagnose. It may be done either by means of the ophthalmoscope, or by testing with glasses, or by means of tests devised for this purpose, which consist of a number of lines crossing each other and radiating in all directions, of which an astigmatic eye will see some more clearly than the rest. After the eye to be examined is brought under the influence of atropine, either a concave or a convex glass, that improves the vision somewhat, will serve as a guide in regard to the refraction of the eye. This glass is to be held before the eye when the patient, looking at the tests will tell us which one of the test-lines, which may be horizontal or vertical or slanting, appear darker than the rest; this will indicate the direction of one of the principal meridians. A stenopæic slit is now held in the direction of this line before the eye and the proper glass, with which the best vision of the regular test-types is obtained, indicates the refraction of this meridian; that of the other is found by turning the stenopæic slit in the opposite direction and selecting also the proper glass for this section of the eye.

By means of the ophthalmoscope astigmatism may be easily discovered. In the direct method we have first the shape of the disc to help us; this does not appear round in astigmatism, but is more or less elongated. The longest axis of the disc corresponds to the meridian of the greatest refraction and is therefore in most cases vertical, or at least nearly so. In the second place, some of the vessels appear distinct, when those of a different meridian are hazy and indistinct. An expert may also be able to determine the refraction of the principal meridians by this method.

In the indirect method we have again the change in the shape of the disc, only that the long diameter of the oval is exactly at right angles to that seen in the direct method, and also the changes, that the disc will undergo, if the lens of the observer is moved nearer to or farther away from the eye. The change will be seen in the long axis of the oval, which from being vertical will become horizontal and *vice versa*. The size of the image also undergoes changes peculiar to myopic or hypermetropic eyes according to the nature of the case. Another plan of finding the degree of the astigmatism is by testing the eye with test glasses and the ordinary Snellen's test-types. After testing with spherical lenses to see whether the principal meridian is hypermetropic or myopic, cylindrical glasses, either convex or concave, as the case may be, are held before the eye, first without, and if the vision is not improved sufficiently, in combination with a spherical lens, and is turned in different directions until the sight of the patient is greatly improved. In fact, the combination of such a glass that improves vision to the normal standard, is the best proof that the astigmatism has been corrected. But very frequently it is quite impossible to correct the astigmatism fully, and in many cases we have to be satisfied with moderate improvement of the visual power of the patient; there is also frequently more or less congenital amblyopia connected with high degrees of astigmatism, which cannot be improved by glasses, and which may be due to a want of proper practice of the retina (see page 300.) This condition may be greatly improved by the use of glasses, and sometimes if these gave only moderate relief in the beginning, they may ultimately give the patient very useful vision.

Anisometropia, or unequal refraction in the two eyes is of very frequent occurrence, especially where the difference is but slight. This condition is of great importance in regard to the selection of glasses for such eyes. The question would naturally arise, what glasses must we give such patients? Let us see first, however, what kind of cases we may have to deal with. (1) In the first place, we may have one eye emmetropic and the other eye ametropic. In such cases no glasses should be given, because the disturbance in the size of the retinal images, and the difference of the accommodative efforts could only have a bad effect on the good eye. (2) Both eyes are myopic, but one more so than the other. In this case each eye should be corrected carefully and glasses should be ordered for each eye, but if the difference is great, more than can be neutralized by a glass of 1 D or one of thirty-six inch focus, it is better to give glasses that will assist the good eye as much as possible. It is not advisable to give the eye with the largest amount of myopia a little weaker and that of the lower degree a little stronger glass and thus to divide the difference, because both eyes would now have poor vision. (3) The same may be said in regard to those cases where there is a different amount of hypermetropia in the two eyes, which occurs also after cataract extractions. In cases of squint, however, a glass of more than $\frac{1}{36}$ difference may be given in order to assist the squinting eye as much as possible. (4) In those cases where one eye is hypermetropic and the other myopic, no glasses are required; because the patient will use the hypermetropic eye for distant vision and the myopic eye for near objects.

Anisometropia is one of the most prolific causes of squ

Difference in the degree of myopia will sometimes result in strabismus divergens and that of hypermetropia is even more frequently followed by convergent squint.

ANOMALIES OF ACCOMMODATION.

These are: 1, presbyopia; 2, paralysis of accommodation, and 3, spasm of accommodation.

1. *Presbyopia*—Pr.; Long-sight. This is due to senile changes of the lens, which in emmetropes takes place generally at the age of forty-five, when the near-point has receded from the eye to such an extent that fine print cannot be read nearer than eight inches from the eye. This condition is caused by a loss of elasticity of the lens, which by this time has become so hard that, in spite of all accommodative efforts on the part of the ciliary muscle, no greater convexity of it can be obtained, than that which enables the patient to see small type at ten or eleven inches; as age advances the lens becomes dryer and less elastic, and the near-point recedes farther from the eye. The change of the diameter of the lens in young persons is considerable, and as the patient grows older it becomes less and less. This want of convexity during accommodation for near objects has to be compensated for by the use of a convex lens placed before the patient's eye. This lens should be strong enough to enable the patient to read ordinary print in about twelve to fifteen inches; it is rarely necessary to give stronger glasses, which would bring the near-point nearer to the eye, say to eight inches, because if too strong a glass is used, distant vision, or vision for objects farther than a few feet from the eye, becomes difficult or impossible. As the change of the lens is nearly uniform in most cases, the amount of presbyopia at certain periods of life is about the same:

At the age of	42	years	a	+ 144	or	0.25 D
"	45	"	a	+ 72	or	0.50 D
"	48	"	a	+ 48	or	0.75 D
"	50	"	a	+ 36	or	1 D
"	60	"	a	+ 18	or	2 D
"	70	"	a	+ 12	or	3 D
"	80	"	a	+ 9	or	4 D

is required to bring the near-point within twelve or fourteen inches from the eye in emmetropic eyes.

The manifestations of presbyopia may be accelerated by a feeble condition of the ciliary muscle, which is often noticed in badly nourished emmetropic patients, or in the beginning of a glaucoma or cataract; in hypermetropia it becomes manifest a little sooner than in emmetropia, and in myopia a little later. It is easily diagnosticated by the inability of the patient to read fine print near by, whilst his vision for distant objects is but slightly or not at all impaired. The degree of the presbyopia is determined by finding out the actual near-point of the patient, and the difference between this and the required near-point, indicates the strength of the glass to be given. If for instance the patient reads fine print not nearer than sixteen inches and wants to read at twelve inches, it is $\frac{1}{12} - \frac{1}{16} = \frac{1}{48}$; a + 0.75 D, or a + 48 glass will therefore enable him to read at the given distance. Hypermetropic eyes require much stronger glasses for reading when they become presbyopic, because in this case we must not only correct the presbyopia but also the hypermetropia. If the amount of the hypermetropia, for instance, is $\frac{1}{12}$ or 3 D, and our patient is sixty years old, we must give him for reading a stronger glass than a + 12, which is the glass that corrects his hypermetropia and gives him the best vision for distant objects; we must add to this the amount of his presbyopia, which will be like 2 D or a + 18. A + 12 and a + 18 added is like a + 7, or 3 D and 2 D are = 5 D. This will be the glass that he needs for reading, and if he desires to have good vision for the distance he must use a + 12 for this purpose. The two glasses may be set in one frame, so that the upper half of the glass represents a + 12 for distant and the lower a + 7 for near vision.

Myopes require much weaker glasses for their presbyopia, and it becomes later manifest than in other eyes, and only in the milder degrees of $\frac{1}{50}$ to $\frac{1}{20}$ will it be necessary to give convex glasses for reading. A myope, who has a myopia of $\frac{1}{8}$ or less, can not become presbyopic, because his near-point can not recede farther from the eye than to the far-point. Presbyopic people should use their eyes only in very good light, because they see much better when the pupil is contracted.

Second sight.—Of great interest, but of rare occurrence, is a peculiar change of the lens in old people. This may, by the imbibition of the surrounding fluids, swell and become more globular, attaining such a high degree of refractive power as to render the eye almost myopic, so that persons which had to use strong glasses before, can now see with much weaker ones, or may even be able to read the finest print without the aid of glasses. This is known as "second sight." A similar condition of the lens with improvement of sight is sometimes seen in the beginning of a cataract, especially if the opacities develop peripherally.

2. *Paralysis of accommodation* may occur together with that of other muscles of the eye supplied by the third or motor oculi nerve, but it is often met with without any other sign of paralysis, except that of the sphincter of the pupil, with which it is associated in nearly all cases. It is frequently due in such cases to traumatism, or it may be one of the sequelæ of diphtheria, or one of the manifestations of syphilis, and the ciliary ganglion is probably the seat of the lesion. Artificially it is produced by the use of atropine or other mydriatics. As such it is only transient and may last, according to the quantity of atropine used, from one to ten days, or even longer.

The principal symptom of this condition is the inability to read or see small objects near by; even large print is indistinct; the vision for distant objects varies according to the refractive state of the eye; emmetropes see perfectly well, myopes or hypermetropes see more or less according to the degree of their ametropia, but hypermetropes see also very much worse near by than myopes. A strong convex glass will, however, replace the accommodation, and an emmetropic patient may be able to read with a + 6, myopes with a weaker glass, and hypermetropes require even a much stronger one.

The paralysis will often be relieved by the use of the faradic current; if it is due to syphilis by the use of mercury and iodide of potassium, if due to traumatic or other causes by strychnine injections, and temporarily by the local application of a solution of eserine (see page 158).

3. *Spasm of accommodation* (apparent myopia) is caused by great accommodative effects of the eye, especially by reading much in insufficient light. It is of frequent occurrence in young hypermetropes and may cause apparent myopia in such eyes.

The patients complain about great pain in the eye after using them for some time and about near-sightedness, chiefly because they have to hold everything close to the eyes. On examining such persons with glasses, we shall find that they actually see much better with concave glasses. If they can see $\frac{20}{Lxx}$ without glasses, they will perhaps be able to see $\frac{20}{xx}$ with a very weak concave glass perhaps with a — 36 or — 1 D; but they cannot read fine print farther than six or eight inches from the eye. This difference between the far-point, being so near to the eye, and the weak concave glass, through which the patient obtains normal vision, should arouse our attention at once. Together with this we find that the pupil is contracted and the anterior chamber narrow, and on using atropine or by means of the ophthalmoscope, we find that the eye is really hypermetropic. Spasm of accommodation is also artificially produced by the use of eserine. The treatment consists in the continued use of atropine and blue glasses, and the occasional use of the artificial leech. Rest is of the greatest benefit to such eyes.

SPECTACLES.

Glasses, how to select and how to prescribe them. In order to test an eye for an error of refraction, the use of test-lenses is absolutely necessary. By the use of the ophthalmoscope we may be able to determine the approximate degree of myopia or hypermetropia, but it is hardly safe to order glasses selected by this method without previously testing the patient's vision with them.

Glasses have to be used for the protection of the eyes and for improving its visual power. Those used for protection are such that either diminish the quantity of light, *smoke-colored*, or those that change the light passing through them, *blue glasses;* these exclude the orange rays of light, which are supposed to be especially irritating. Such glasses ought to have the shape of a shell and are called coquilles. They come close to the eye, so as to exclude the light thoroughly, but they must not be used for fine work, nor should they be used in a dark room; they are more for the street than for the house. There are different shades of blue glasses, which are expressed as A B and C. A is light and C a dark blue. Goggles with side pieces attached to them afford also great protection.

The use of colored glasses is indicated in all affections of the eye in which the irritating effect of bright light is to be avoided. Corneal, iritic, retinal and some forms of conjunctival diseases call for their use, and in these cases blue glasses are especially useful. Stained or dark glasses are, however, also of great service to perfectly healthy eyes when they are exposed to the effects of too much light, such as the bright sunlight or the reflex of a large surface of snow. In some affections of the lids, blepharadenitis for instance and in catarrhal affections of the conjunctiva, bright lights are apt to increase the hyperæmic state, and in these cases just mentioned smoke-colored glasses are of great service.

Sometimes it will be found of great service to add a faint tint of blue to concave or convex lenses; especially when there is some hyperæsthesia of the retina present, these glasses may give prompt relief.

Another form of glasses are stenopæic glasses; they consist of a metal plate with a round or slit-like opening in the centre in most cases, but this has to vary according to the seat of opacities of the cornea or lens, for which they are used. The object of these glasses is to prevent diffusion of light and to adapt them to the eyes in such a way, that the rays of light have to pass only through a clear portion of the cornea or lens. They are therefore of great help in some forms of partial cataract and in opacities of the cornea. They are not used much.

Spherical glasses.—S is the sign that is used to indicate this kind of lenses and C stands for cylindrical glasses (page 344). Spherical glasses, which are either concave and convex, are used in the great majority of cases. They are ground on a sphere, which is concave for convex lenses and convex for concave glasses. The latter have the property of causing a divergence, convex glasses that of producing convergence of the rays of light passing through them. Concave glasses are therefore used for myopic, convex ones for hypermetropic and presbyopic eyes. These lenses may be perfectly plane on one side and concave or convex on the other (*plano-concave* or *plano-convex*), but those that are bi-convex or bi-concave are preferable, or they are concave-convex or convex-concave, and are called *periscopic glasses.*

The strength of these lenses is determined by their focal length, and they are numbered accordingly. The focus is that point at which the different rays of light, after passing through the lens, are united. In the convex lens this point is behind the lens; it is therefore a positive focus and the + sign is used to indicate the convex shape of a glass. The focus of a concave glass, however, is in front of the lens; it is a negative one and a — sign is used to designate these glasses. In numbering lenses the old system of inches or the new metric system may be resorted to. In the former a lens of a focal length of one inch is taken as a unit, and the different glasses are expressed by a fraction whose numerator is one and whose denominator is the focal length of the glass in inches. A lens of a focal length of sixteen inches, which is convex, is therefore expressed by the sign $+\frac{1}{16}$ or simply by + 16. In the metric system a lens of a focal length of a metre, which is like 37 French or $39\frac{3}{8}$ German or English inches, is taken as a unit, and this is called a dioptric (D); a lens of 1 D is therefore like a lens of a 36 inch focus (this is accurate enough for practical purposes). This system does away with the difference of the inch in different countries and with the inconvenience of using fractions. Compared with the old system (nearly all glasses used to be ground according to the French inch) a lens of 2 D must be twice as strong as that of 1 D, and is therefore like $\frac{1}{18}$; one of a half D is only half as strong and therefore like $\frac{1}{72}$.

0,25	D	or	$\frac{1}{4}$ D	is	like	$\frac{1}{144}$
0,50	"	"	$\frac{1}{2}$ "	"	"	$\frac{1}{72}$
0,75	"	"	$\frac{3}{4}$ "	"	"	$\frac{1}{48}$
1,	"	is	like			$\frac{1}{36}$
1.5	"	"	"			$\frac{1}{24}$
2,	"	"	"			$\frac{1}{18}$
3,	"	"	"			$\frac{1}{12}$
4,	"	"	"			$\frac{1}{9}$
12,	"	"	"			$\frac{1}{3}$
18,	"	"	"			$\frac{1}{2}$

of the old system.

In order to tell what a lens we have to deal with, in examining for instance a glass that our patient has been using, we must remember that looking at an object through a convex lens and moving it from one side to the other, the object appears to move in an opposite direction and looks slightly magnified; if seen through a concave glass, the object moves in the same direction in which this is moved and looks a little smaller.

In order to determine of what strength the glass in question is, we must see what lens of our test-case will neutralize it completely, so that it appears like plain glass, through which we can see near as well as far objects as distinctly as if we were looking through a window-pane; nor must the object move in the least, when the two lenses are moved. If we find that the lens, which neutralizes the glass in question, is a convex lens + 18 or + 2 D, the patient must have used a – 18 or – 2 D (concave) and must be myopic. If the glass is a convex glass, we can also determine the strength of the lens by the distance at which the image of a distant object, for instance the bar of a window-frame, is distinctly focussed on the wall or on a sheet of white paper. The distance of such an image from the posterior surface of the lens is the focal length of the glass.

In prescribing these glasses we say simply, ℞. S – 2 D; which means that for each eye a concave glass of 2 D or a – 18 should be given. If we desire to order a different lens for each eye, we must write:

℞. O. d. (oculus dexter, or right eye) s 2 D.
O. s. (oculus sinister, or left eye) s 1, 5 D.

It makes little difference whether the glasses are made in the shape of eye-glasses or spectacles. For ladies or myopes, or glasses that are used only once a while, nose-glasses may be preferable.

Cylindrical glasses (c) are not ground on a sphere but on a cylinder, the long axis of which is indicated by a small line at the edge of the glass. They are like concave or convex spherical lenses in one meridian and like plain glass in the other one, which is at a right angle to the first. They are called for by the sign c + or c – as the case may be, giving at the same time the direction of the axis of the cylinder by the degrees of a hemisphere, beginning with the enumeration at the left-hand side; 90° would indicate a vertical direction, 180° that of a horizontal direction of the cylinder. In ordering a combination of glasses, s and c together, we express it by the following formula:

℞. S – 12 ○ c – 24 axis 90°.

If the one meridian is convex, the other concave, as in mixed astigmatism, the order for such glasses would be:

℞. C + 12 ax. 90° c – 24 ax. 180°.

These lenses must never be used in the shape of eye-glasses, as they, by hanging down at the sides, would change the direction of the axis of the cylinder. They should be carefully centered, so that the centre of the glass is exactly in front of the pupil of each eye.

Prisms are needed only in exceptional cases; the degree of the prism indicates its strength and is expressed in ordering such glasses, as, prism of 10° base inwards or outwards as the case may be. It is always best to divide the prism for the two eyes, giving the weaker one a little stronger glass; if there is, for instance, an insufficiency of a muscle of 10° to be corrected, we give a prism of 6° for the weak and one of 4° for the normal eye (see page 66.) A prism has the power of bending rays of light in a direction towards its base; if the base is held inward, that is, toward the nasal side, the rays of an object are bent in such a way as if they came more from the temporal side, and convergence is not called for to such an extent as before. The internal recti muscles, when weak, will be rested by the use of these glasses with the base or thicker end inward. If the external recti are weak the base must be outwards. If a prism is held before one eye only, it will, if strong enough, cause diplopia; the effect of a weaker prism is overcome by the action of the muscle. The internal rectus, being very powerful, can overcome a much stronger prism than any of the other recti muscles.

How to select glasses.—If a patient comes to us for glasses we must, after excluding amblyopia, due to diseased conditions of the deeper parts of the eye, or opacities of the cornea, lens or vitreous body, find out what he can see in the distance with each eye separately; this has to be noted carefully. If he can read the last line of Snellen's test-types at a distance of twenty feet, his vision is normal and myopia may be excluded. We must not be led astray by the fact that such a person tells us that he sees a little better through a weak concave glass, which we hold before his eye, because he can overcome the divergence caused by these glasses readily by an effort of accommodation. Myopic persons have not perfect vision for the distance, and their vision may be so reduced that they are not able to see even the paper containing the test-letters at a distance of twenty feet. If this is the case, we may as a rule exclude hypermetropia, and if no amblyopic condition exists, we shall find that the patient is greatly benefited by concave glasses. As we have seen, when speaking about myopia, it is necessary to give the weakest concave lens that the patient has the best possible vision with. If he sees the last line of the test-types with a — 36, a — 32 and a — 24, we must order a — 36, or — 1 D, because this is the weakest glass and expresses the degree of his myopia. We must now try the other eye, and after finding the proper glass for this one also, we must try what the patient can see with the two, and if we find that he sees perfectly well with them, such lenses may be ordered. If the two eyes are not alike and the difference between the glasses is great, the patient does not see well through them and we may have to be satisfied by correcting the vision of the best eye (see page 347.)

Before ordering concave glasses it is well to see whether the far-point of the patient is about the same as the focal length of the lens. If he is myopic and requires a — 18 or 2 — D, he ought to be able to read fine print as far as 18 inches from the eye; if he cannot do this, reads it perhaps at 8 inches only, the use of atropine must be resorted to in order to find the true state of refraction; it might be due to a spasm of accommodation (see page 350). An ophthalmoscopic examination should also be resorted to in order to verify the result obtained by the use of glasses.

If our patient is hypermetropic the selection of glasses may be very difficult. Such a person, complaining much about accommodative asthenopia due to his hypermetropia, comes to us for glasses, and testing his vision we may find that he can read the last line of the test-types; this does not prove that he is not hypermetropic. He has normal vision but by no means a normal eye; we must not tell him that he sees perfectly well and is not in need of glasses, but must try to determine whether he can see as well or perhaps a little better through convex glasses, and if this is the case, we must select the strongest convex lens with which he can distinguish the last line. This glass represents his manifest hypermetropia, and will in most cases be the one suited for his condition. (See hypermetropia, page 342).

If a patient can see only $\frac{20}{xl}$ of the test-types and is myopic, a concave glass of the proper strength will give him perfect vision; but all convex glasses will make the letters look blurred; if he is hypermetropic he will see better through convex lenses; but if too strong a glass is held before his eye he will complain that it blurrs the sight, and the same condition is caused by concave glasses, because a person with manifest H. has used up all his accommodation and cannot overcome the divergence caused by the concave glass.

The glasses found by this method must not be used by myopes for reading or near work (see page 334), but hypermetropes may use their spectacles for reading as well as for the distance, except when they are more than forty years old. In this case they are presbyopic, and according to the amount of the presbyopia the glasses have to be stronger for near work, but not so for the distance.

By holding a weak convex lens, say a + 60, or a concave glass of the same strength, before the glasses selected, we are able to tell whether these are the right spectacles for the patient or not. If, for instance, these are concave glasses, and the vision is improved by a weak convex lens, we know that the glasses are too strong and should order weaker ones instead.

If the vision of an old person is good and is not improved for the distance, we should order convex glasses varying in strength according to the amount of the presbyopia; but if the vision for distant objects is improved by convex lenses, the glasses for near by must be so much stronger than those that correspond to the degree of the presbyopia alone; and if the vision is improved by concave glasses the presbyopic spectacles have to be weaker.

If the vision of our patient is not much improved by spherical glasses he may be astigmatic, and must be tested for this with cylinders. (See page 344).

In order to test a patient for glasses it is necessary to be provided with a trial-case, that contains a number of convex and concave spherical and cylindrical glasses, and if possible also prisms; but the selection of prisms or cylindrical lenses requires a great deal of nicety and care, and is not often called for; the plainer test-cases do not contain them at all. Complete trial-cases are generally imported and are very expensive; the smaller ones, such as devised by Dr. Loring (Hunter, 1132 Broadway), or by Dr. Cutter (William Wood & Co.), or by Drs. Roosa and Ely (Meyrowitz Bros.), will answer in most cases. These trial-cases contain also test-types for near and distant vision.

By request I add a list of those instruments that are necessary for ordinary operations on the eye, and which will meet the wants of the general practitioner:

One plain Wire Eye Speculum.
Two Cataract Knives (Noyes).
One Iridectomy Knife.
One Canaliculus Knife (Agnew)).
One Cystotome and Scoop.
One Cataract Shell Scoop.
One Bowman's Stop Needle.
One Straight Cataract Needle.
Two Strabismus Hooks.
One Lid Retractor.
One Prout's Reversible Entropium Forceps.
One small Scalpel.
One pair of Curved Iris Scissors.
" Curved Strabismus Scissors (blunt).
" Fixation Forceps (Spring).
" Cilia Forceps.
" Curved Iris Forceps.
" Needle Forceps (Prout).
One set of Bowman's Probes, 1–8.
Three small Curved Needles.
One Cylinder (Artificial Leech).*

* These instruments of superior workmanship are put up in a neat case by Messrs Shepherd & Dudley and John Rynders & Co., New York.

DIFFERENTIAL DIAGNOSIS OF THE REFRACTION OF AN EYE.

	Hypermetropia. H.	*Emmetropia.* E.	*Myopia.* M.
1. Optic axis compared with that of a normal eye.................	Shorter.	Normal.	Longer.
2. Distant vision is improved by....	Convex lenses.	No. glasses.	Concave lenses
OPHTHALMOSCOPIC EXAMINATION.			
A. Direct Method.			
3. Image of fundus at some distance from the eye, as compared with that of the normal eye.........	Smaller.		Larger.
4. If the observer's head is moved the image moves	In the same direction.		In a contrary direction.
5. The position of the image seen is	Behind the eye.		In front of the eye.
6. Image of fundus close to the eye can be seen by means of.......	*Convex lenses,* but also without glasses and with concave ones.	*Without a lens,* but also with a concave one.	*Concave lenses* only.
B. Indirect Method.			
7. Image of fundus is best seen at a distance of.....	About 30 in.	About 20 in.	About 12 in.
8. Size of image compared with that of a normal eye..............	Larger.		Smaller.
9. If the lens is moved farther from patient's eye the image........	Becomes smaller.	Remains the same.	Becomes larger.

PART II.

THE EAR.

INTRODUCTION.

THERE is quite an analogy between audition and vision. The principal part of both is performed by the brain, and the peripheral organs are only the means of either seeing or hearing. The sound-waves are condensed by the ear and the impressions received are transmitted to the brain by means of the auditory nerve, where they are perceived as sound. If any portion of this chain, which conducts the sound, is defective, hearing is impossible or greatly impaired. If the cerebral centres, or the parts from which the auditory nerve takes its origin, are diseased we do not hear; if the auditory nerve is affected, atrophied or compressed by a tumor, the impressions received in the cochlea or labyrinth are not transmitted to the brain and we do not hear. If the internal ear, where the terminal fibres of the auditory nerve are distributed, is affected by disease or injury, hearing is again impossible, because no impression of the sound-waves is received. If the more external portion of the auditory apparatus is defective, the waves of sound are more or less altered and hearing again is not perfect, or it may be lost altogether; but as a rule impairment of this portion of the apparatus is not so apt to make a person completely deaf; if, however, the nerve-elements of the ear are affected, total deafness is, as a rule, to be expected.

The auditory apparatus is composed of a number of sections, and the more delicate parts of it are protected by strong bony surroundings; the more delicate, the farther back they are, distant from any injurious influence. Indeed diseases or affections of the ear would be of very rare occurrence if it was not for one weak spot, the mucous membrane lining the cavity of the middle ear, which being connected by means of the lining membrane of the Eustachian tube with that of the throat, is the cause of more than ninety per cent. of all ear troubles, and of all the mucous membranes of the body this is the one that is most frequently seen to be the seat of disease. The inflammatory processes, which are here so frequently found, may easily extend through the Eustachian tubes to the middle ear and thus be the cause of great changes in this part of the auditory apparatus.

Audition is the act of perceiving the impressions of sound. The sound-waves are, however, of a very complex nature; they are different for instance for each vowel, and these are again greatly modified by those of the consonants. These waves are collected by the auricle and directed to the external auditory canal, which has a slight turn like that of a shell; its shape facilitating the passage of the sound to the membrana tympani. The membrane itself conducts now the vibrations and transmits them by means of a delicate chain of connecting bones, acting like the springs of a wagon, to the inner ear, which they reach greatly modified in intensity. In order to facilitate the vibrations of the drumhead and the transmission of these vibrations to the inner ear, the cavity of the middle ear is filled with air, and is connected on the one side with another reservoir of air, the mastoid cells, and on the other side by means of the Eustachian tubes with the cavity of the mouth. In this manner an exchange of air or changes in the tension of the air of the cavity of the tympanum are readily accomplished, but tension of the membrane itself is regulated by special muscles. After reaching the internal ear the sound-waves have to pass through a fluid surrounding the membranous portion of the labyrinth, before they reach the terminal auditory nerve-fibres, which are distributed here. The nerve itself is so well protected that injuries or concussions of its fibres occur only in exceptional cases; they may suffer when the sound-waves are extremely powerful or more or less confused and are continued for a long time, as is the case with boiler-makers.

The quality or pitch of the sound is distinguished by the cochlea, which is a part of the inner ear. In this organ the terminal fibres of the nerve are supposed to be tuned to vibrate in sympathy with all the different notes that we hear in the musical scale. These notes produce sound-waves of regular periodic vibrations. Irregular vibrations are known as noises and they are perceived by the membranous labyrinth, which is supposed to be the organ for the quantitative perception of sound-waves.

Sound is, however, conveyed to the auditory nerve not only by ærial conduction but also by another channel, by the bones of the head. Vibrations transmitted in this way must, however, be more intense than those conveyed by the air, and they must be conducted and transmitted to the bones by special instruments. This is done by the audiphone or by the tuning-fork.

In this manner an ear which is not accessible to the sound-waves transmitted through the regular channel, the external and middle ear, can be made to hear by conducting the waves to the teeth, whence they are transmitted to the bony portion of the internal ear and ultimately to the nerves of the membranous portion of this organ. An ear that does not receive sound-waves by means of ærial conduction is apt to hear the sound transmitted through the bones of the head, for instance the vibrations of a tuning-fork, more distinct than an ear which perceives and receives at the same time sound-waves through the ordinary channel, whilst in the normal condition former vibrations are hardly perceived.

Besides the regular, periodic and the irregular vibrations, which we appreciate, the former as musical sounds and the latter as noises, we distinguish also intensity and pitch of the vibrations; the first depends on the breadth or amplitude, and the latter upon the number of the vibrations emanating from a sounding body in a certain space of time.

According to the breadth of the sound-waves, their number remaining the same during a certain period of time, they are loud or low; but if the vibrations vary in number, the sound-waves reach the ear in a more or less rapid succession, and if they are very numerous in a certain space of time, the pitch is a high one, and if there are few during the same period, the pitch is a low one. The number of these vibrations may vary from 45 to 40,000 and more per second.

MEANS OF DIAGNOSIS.

In order to be able to examine the different portions of a diseased ear, we must be able to see down the entire external auditory canal to the membrana tympani. If the canal were a perfectly straight tube this would be comparatively easy, but it does not only change in calibre at different places, it forms also a more or less marked curve with its convexity upwards, which has to be straightened before the deeper parts are sufficiently exposed to be thoroughly examined. This curvature of the canal is caused by the junction of the cartilagenous portion with the bony part of the external auditory canal. The direction of these two portions of the canal being somewhat different, more or less of an angle is formed at the point where they meet. As the direction of the bony portion cannot be changed, we must, by lifting up the cartilagenous portion, remove the angle; this is done by lifting the auricle of the ear with our fingers. The use of an aural speculum and a condensing mirror with a perforation in the centre, called an *otoscope*, is now required to illuminate the parts, which are easily seen by the observer, if he looks through the central perforation in the mirror.

In order to get a distinct view of the membrane it is necessary that the observer should follow these rules, as an otoscopic examination differs in this respect from a laryngoscopic one, in which it is not necessary that the observer looks through the central opening of the mirror. As the membrane of the tympanum is not placed at right angles with the auditory canal, but is more or less inclined, it is necessary to look well forwards in the direction of the nose, and also towards the upper portion of the drumhead, where certain prominent parts will be readily recognized, which may serve as landmarks, where to look for the rest of the membrane. Looking in this direction we shall find a marked prominence caused by a projecting portion of one of the ossiculi of the middle ear, viz., that caused by the short process of the malleus. The membrane is more or less stretched over it, and this gives it a white, somewhat glistening appearance; as it occupies a place in the upper and posterior portion of the drumhead, the rest of the membrane must be below and a little in front of the process. In the normal state the appearance of the drumhead is but little different from that of the external auditory canal, and its direction may be inclined to such an extent that it appears more as a continuation of the canal and not as a distinct and separate organ. This is especially the case in the ears of children. If, on the other hand, there is congestion of the vessels of the membrana tympani, changing its appearance from an almost white transparent to a decided pink or scarlet one, its recognition is very easy; if, however, the entire auditory canal or that portion of it being next to the membrane is also congested and otherwise changed, the drumhead may be very difficult to recognize; also, in cases of very marked retraction of the drumhead, as we see it in chronic catarrhal affections of the middle ear, the exact position of the membrane may be difficult to see. In these cases the short process should be looked for, and from here the other parts of the drumhead can be made out easily.

The *specula* used for the examination of the ear must be of different size, because the calibre of the bony portion of the external auditory canal differs in different individuals and is especially small in children. The speculum, at least the narrow portion of it, should be oval and not round, because the inner portion of the canal is more or less oval, with the long diameter in an almost vertical direction. The introduction of a round speculum into this canal would either cause more or less painful sensation, or it would have to be very small and would on this account increase the difficulties of the examination. In most cases the speculum has to be introduced as far as possible for an examination of the drumhead, but it must be remembered that sometimes, especially in small children, the drumhead is only a short distance from the meatus auditorius externus, and that we have to be careful not to injure the membrane by pushing the speculum in too far. In fact, the drumhead is so near to the meatus in small children that it can be examined sometimes without the use of the speculum, simply by lifting the auricle.

The ear-specula are made of different material and of different shapes. I prefer the Gruber speculum, made of silver, with a round expansion of the upper part and a narrow oval lower portion. After introducing the speculum, it should be held with the thumb and forefinger, and the other fingers should be used to raise the auricle sufficiently to straighten the auditory canal.

The *otoscopic mirror* should be of at least three inches in diameter and have a focal distance of six inches. It should be held by the observer's right hand close to the eye; but in operations or other manipulations, where both hands are required, it will be found most convenient to have the mirror held to the forehead by an elastic head-band.

The light used for aural examinations may be either daylight or artificial light. In most cases, where distinct vision is necessary, the light coming from the north will be found to be the best and should always be resorted to if possible, except for operations, where the bright light of an argand gas-burner or that of a student's lamp will be found to be more serviceable. The electric light is perhaps the best of all; even the deeper parts of the cavity of the middle ear may be seen by it. In regard to the illumination and examination of the drumhead, it must be remembered that the observer has to have his eye in a line corresponding to the direction of the bony portion of the canal and not in that of the cartilagenous one.

This is perhaps the best place to speak of other instruments that are necessary as well as of their application. One of the most important of these is a good syringe. This should be made of hard rubber and have a bulbous point, so that it cannot be inserted too far, which might lead to injuries of the drumhead. A ring must be attached to the piston, so that it can be worked with one hand, while the other one is used to lift the auricle.

This syringe will serve for most purposes, for cleansing the ear and especially for the removal of secretions and foreign bodies, but it should not be used for making warm applications to a patient suffering with inflammatory conditions of the middle ear or the membrana tympani, especially if there is no perforation present. In these cases a nasal douche or a fountain syringe, by which a gentle current of water can be made to enter the meatus and rinse out the canal, is preferable. Injections made with a hard rubber syringe are apt to be too powerful and may cause severe pain.

A *cotton-holder* is used for cleaning the ear and also for making applications of remedies to the diseased parts. For this purpose a small tuft of cotton may be coiled around the end of the holder; if it is necessary to leave the cotton in the ear, the instrument is easily removed by turning it in an opposite direction. A common probe can be substituted for this purpose.

Politzer's inflator or an air-bag is used for the inflation of the tympanic cavity through the Eustachian tubes. This has been one of the most valuable inventions of aural surgery. The bag should be supplied with a valve, which prevents the fluids of the nose from entering the bag after the act of inflation; it will also be of great service in many cases to have a little chamber connected with the nose-piece of the inflator, through which the air has to pass before it reaches the nasal cavity. In this chamber remedies may be so placed that the air becomes impregnated with the vapors of these drugs. Iodine and iodoform are generally used for this purpose.

Inflation of the middle ear can be accomplished by means of the air-bag alone; this is a very easy method which is frequently resorted to. It is done by forcing the air into the Eustachian tubes during the act of swallowing, when the mouth of these tubes opens and the soft palate shuts off the nasal space from the pharynx. If, at the moment of deglutition, the nose-piece of Politzer's inflator is introduced into one nostril and the alæ nasi are tightly compressed over it, the air forced from the bag, finding no other means of egress, except through the Eustachian tubes, will naturally enter these and produce an inflation of the tympanic cavity. The most convenient way is to let the patient take a sip of water and keep this in his mouth, until at a given signal, for instance as soon as the physician counts *three*, he has to swallow it. At this moment the mouth of the Eustachian tube opens and the inflation is easily accomplished. Another very convenient method of using Politzer's bag is to direct the patient to blow with his mouth closed and tightly drawn together; if the air-bag is now used, it is sure to inflate the cavity of the middle ear if the Eustachian tube is open. In children who cannot be made to swallow at a given moment, it is easy to inflate the ear while they are crying.

The Eustachian Catheter.—Inflation of the ear can be generally accomplished without much trouble, but at times it may be found to be a difficult task, probably because the mouth of the Eustachian tube is swollen to such an extent that it does not open sufficiently during the act of swallowing, or because hypertrophic masses compress it. If therefore the inflation of the tympanic cavity cannot be accomplished by the above methods, the use of the Eustachian catheter may become of great service. This instrument is made of silver or hard rubber, and consists of a straight tube about six inches long, which is slightly curved at one end, and has a conical expansion at the other. This catheter is introduced through the nares by hugging carefully the floor of the nasal cavity and pushing it backwards, until it comes into contact with the posterior wall of the pharynx. If this is reached the instrument has to be withdrawn about a quarter of an inch and turned outwards and upwards; by this manœuvre the curved end of it will enter the mouth of the Eustachian tube and the cavity of the middle ear can be inflated readily, except in those cases where an obstruction in the tube itself exists, by attaching the conical end to the air-bag and forcing the air through the catheter and through the Eustachian tube into the middle ear. The conical end of the catheter is arranged in such a way that it can be easily connected with the air-bag. Here is also a little ring attached to it, having the same direction as that of the curve and always pointing in the direction of the ear into the Eustachian tube of which the catheter has been introduced. Sometimes the introduction of the catheter will be difficult on account of cicatricial contractions, the result of inflammatory processes of the mucous membrane of the posterior nares, or the mouth of the Eustachian tube may be completely closed by posterior hypertrophy of the inferior turbinated tissue. If these masses are large, they should be removed by means of Jarvis' wire snare Ecraseur, after which the introduction of the catheter will be easy; sometimes the hearing will improve at once after this operation. After blowing the nose, and thus moistening its mucous membrane, by pressing the upper lip gently downward and by holding the catheter first in a vertical line with the body, but giving it a perfectly horizontal direction as soon as it has entered the nose, the introduction of the Eustachian catheter is made comparatively easy. The patient should be directed to hold the head a little forward and breathe through the mouth meanwhile. But some skill is necessary and the introduction of the catheter is by no means agreeable to the patient; in most cases its application may be supplanted by the use of Politzer's method.

Valsalva's method.—Another very simple method of inflating the cavity of the middle ear is that known as Valsalva's method. The patient has to hold his lips and nose firmly together while he attempts to blow; the air cannot escape and will force its way into the cavity of the middle ear. The only danger is that the patient, seeing the instantaneous improvement in his hearing power, is inclined to resort to it too often, and thus may do harm to the diseased as well as to the good ear. There is one great objection to the first and third methods, those of Politzer and Valsalva, and this is that both ears are inflated each time. The other ear, even if perfectly healthy, may actually suffer in some cases from the effects for some time.

Diagnostic tube.—The fact that air has been forced into the cavity of the middle ear is easily appreciated by the patients, but if they are not positive about it or are not able to appreciate it, we may have to resort to the use of the diagnostic tube. This consists of a piece of rubber tubing with two ear-pieces attached to it; one of them is to be introduced into the patient's ear, the other one into that of the physician. Whenever air is introduced into the middle ear of the patient it can be plainly heard by the determine the hearing power which a patient possesses. Acuteness of hearing is of course a matter of the greatest importance to the patient, and he may not seek medical advice until this faculty is impaired.

For testing the hearing-power of a person we may resort to three different methods; these are:

1. Ordinary conversation.
2. The watch.
3. The tuning-fork.

There is no positive standard of normal hearing, nor do we have a precise method of defining an impairment of it; even the above tests are more or less imperfect, and there may be quite a difference in regard to the results obtained by them. This is especially true of the first and second method; a patient may for instance hear the watch quite a distance from the ear, but be almost deaf to ordinary conversation, and *vice versa.*

The most reliable test to determine the amount of hearing of a patient is the tick of a watch. This should be heard by a normal ear at thirty-six inches; if, however, it is only heard at six inches, the hearing-power is only like $\frac{6}{36}$ or $= \frac{1}{6}$. Each ear has to be tested, and the ear that is not tested is to be closed by placing a finger or a handkerchief over it; the patient should not be allowed to see the watch and the latter has to be moved slowly from a great distance toward the ear. The distance at which it begins to be heard is the true hearing distance of the patient. If the watch is not heard even close to the ear, it should be gently pressed against it, and the hearing-power in such a case is to be recorded as "hears watch on contact." Sometimes the watch is not heard at all even on pressure, but still the voice may be heard tolerably well. It is absolutely necessary in testing for the ability to hear ordinary conversation, which should be heard by the normal ear at about twenty feet, that the patient does not see the mouth of the physician, because persons that cannot hear well are apt to learn by the motion of the lips what is said. In ordinary speech the variation of the vibrations of the sound-waves are between sixteen and four thousand per second, but the more frequent the vibrations the greater will be the distance at which the sound is heard. Unfortunately the want of uniformity of the tick of different watches and the great difference of ordinary speech, render these tests of proximate value only.

If the hearing of one ear alone is impaired, great care must be taken to exclude the hearing of the good ear; this is therefore to be closed by the hand, or better, by a handkerchief and turned from the source of sound. In making these tests it is also necessary that the room in which the observations are made be away from all noise; even the tick of a clock in the room should be stopped during the examination.

The tuning-fork is of special service in those cases in which the tick of the watch is not heard. In these cases the question would naturally present itself to us, does the patient hear at all, is his auditory nerve affected, or do we have a disease of the middle ear to deal with? We have seen before, that if the sound-waves do not reach the ear by the meatus or by ærial conduction, the vibrations transmitted through the bones of the face are heard more distinctly. If a tuning-fork is made to vibrate and its handle is then placed upon the forehead, or especially upon the closed teeth, the vibrations will be heard more distinctly on the affected side, and if both ears are diseased, they will be heard by the worst ear most distinctly. If, however, the auditory nerve is affected, the tuning-fork will not be heard at all on the affected side, but only by the good ear. The tuning-fork is therefore more of diagnostic value in regard to affections of the middle and internal ear than as a test for the hearing power of a patient.

Affections of the ear may be conveniently divided into those of the: 1, *External ear*, which includes the diseases of the auricle and the external auditory canal; 2, into those of the middle ear, which comprises the cavity of the middle ear, the membrana tympani, the mastoid cells and the Eustachian tubes, and 3, into those of the internal ear, with the vestibule, the cochlea, the semi-circular canals and the auditory nerve.

In the following chapters I have tried to follow the plan laid down in Dr. St. J. Roosa's admirable work on the ear, as far as practicable.

CHAPTER XVIII.

THE EXTERNAL EAR.

THE external ear is composed of the auricle and the external auditory canal. The most external portion of it, the auricle or pinna, is of varying size and shape in different persons; it is composed principally of a funnel-shaped fibro-cartilage, which presents many elevations and depressions, and is covered with integument. It is continuous with the outer cartilagenous portion of the external auditory canal, and is attached to the malar and temporal bones by means of elastic fibres. It is also held in place by muscular tissue and the integument of the head. The depressions and elevations of the pinna, which give it the peculiar shape, are called (1) the helix, this is the outer rim or border; parallel with this is another ridge, (2) the anti-helix, and between these two elevations is a depression called (3) the fossa of the helix, and the upper expanded portion above and in front of the anti-helix is, (4) the fossa of the anti-helix. Anterior to the central opening (5) the meatus auditorius is a triangular projection, (6) the tragus, which is generally covered with hair, and the prominent portion behind the meatus, just at the beginning of the lobe, (7) the anti-tragus. A large depression between the anti-helix and the meatus is called (8) the concha, and another, the lowest portion is (9) the lobe of the ear; this is devoid of cartilage and is principally composed of fibrous connective tissue.

The auricle is abundantly supplied with blood-vessels; the arteries are the auricular branches of the occipital, temporal and the posterior auricular arteries. The corresponding veins accompany the arteries. The nerves are the auricular branches from the facial, the pneumogastric, and inferior maxillary nerve, and the auricularis magnus from the cervical plexus. The muscular tissue of the external ear is of little importance; there are two sets of muscles, those connecting the pinna to the head and those that extend from one part of the cartilage of the pinna to another. The first are the attollens aurem above, the attrahens aurem in front, and the retrahens aurem behind the ear. Those of the pinna are the helicis major on the anterior margin of the helix; the helicis minor at the most anterior portion, just above the meatus; the tragicus upon the outer surface of the tragus; the anti-tragicus at the outer part of the anti-tragus, and the transversus auriculæ and the obliquus auris, both on the posterior surface of the pinna.

The second portion of the external ear is the *external auditory canal, Meatus auditorius externus.* It is that portion of the ear that extends from the auricle to the membrana tympani; it is about 30 mm. long and composed of two sections, the cartilaginous and the bony portion; but these two do not run in exactly the same direction; the one has an upward and inward course, the second a more directly inward and a little downward one. They do not form therefore a straight canal, but one that is more or less curved at the junction of these parts; it can, however, be easily straightened by raising the cartilaginous portion. This is of importance in examinations of the ear or in syringing this canal. The outer cartilaginous portion is about 10 mm. long and is formed by a prolongation of the cartilage of the pinna inwards, and is firmly attached by an irregular margin to the bony portion. It does not form a perfect canal, being deficient in the upper and posterior portion; it presents also two or three deep vertical fissures (incisuræ Santorini). This portion of the canal is freely movable and surrounded in front and below by the parotid gland, and abscesses of these will sometimes be discharged through the fissures of the canal and the meatus auditorius, and this may give rise to mistakes in regard to the starting-point of a purulent discharge.

The bony portion of the canal is in the adult about 15 mm. long, but at birth no bony canal exists, and the membrana tympani is right behind the cartilaginous portion; it is therefore very superficial, and may be easily seen without the aid of the otoscope or speculum; later as the bone develops the membrane recedes. The bony canal is narrower than the cartilaginous portion; its course is slightly curved and the anterior and the inferior wall is longer than the rest, and on this account the membrana tympani has an oblique direction. The canal is narrower and of an oval shape at the inner portion, but expands again near the membrana tympani. The canal is lined with integument and not with mucous membrane; the lining membrane is very thin and closely adherent to the bone; it extends to the membrana tympani and is covered with hair, especially the anterior portion of it; it contains also a number of sebaceous glands. Deep in the subcutaneous tissue of the cartilaginous portion lie a number of ceruminous glands, which secrete the ear-wax, cerumen; this consists of saponified fat and coloring matter, and becomes mixed with epithelial cells of the lining membrane of the canal. The canal is in close relation in front with the articulation of the lower jaw, behind with the mastoid cells, and above with the mastoid cells and the middle fossa of the skull.

The blood-vessels are derived from the posterior auricular, the temporal artery and from the deep auricular branch of the internal maxillary artery. The venous blood enters the temporal vein. Many smaller veins leave the canal near the tragus, and it is in this region, either to the inner or outer side of the tragus, that leeches will prove most efficacious in relieving congestion or inflammation of the ear. The nerves are derived from the third branch of the fifth and of the pneumogastric nerve.

Affections of the external ear may be divided into those of the *auricle* and those of the *external auditory canal*. a, Those of the auricle are*:* 1, *malformations ;* 2, *tumors ;* 3, *cutaneous diseases ;* 4, *injuries*.

1. *Malformations*.—These may be of various kind and are congenital or acquired. If congenital, the malformation may consist in a partial or complete arrest of development, and the auricle may be entirely absent on one or both sides. There is frequently complete closure of the canal associated with it; if this is the case, the patient does not hear, and there is probably often also an arrest of development of the internal ear and the nerve-elements. If only the auricle is absent or rudimentary, there is generally marked impairment of the acuity of hearing. The treatment is unsatisfactory; only little can be accomplished in these cases by surgical interference. Other malformations may be of various kind; frequently there is a long horn-like projection from the anterior portion of the tragus, or there may be fissures in the cartilage of the ear. The lobe is also frequently deformed, but in this location the deformity is apt to be acquired. This latter variety of deformities are frequently the result of disease (eczema), maltreatment or injury; they may sometimes be relieved by surgical interference and in some cases by pressure applied for some time.

2. *Tumors of the auricle* may be divided into (1) fibrous, (2) atheromatous, (3) malignant, and (4) vascular tumors.

1. Fibrous tumors of the auricle are almost exclusively found in the lobe; they consist of fusiform cells and connective tissue fibres and are due to an irritation, caused by wearing earrings; they are of much more frequent occurrence amongst the negroes than with other races. They vary considerably in size, and, as

they are in the lobe, their removal is comparatively easy. These tumors may make their appearance after heavy ear-rings have torn the lobe, and if this is the case their removal ought to be followed by the careful apposition of the two parts of the lobe. If the lobe is not torn, they may be easily removed by a V-shaped incision. They are apt to recur after an operation.

2. Atheromatous or sebaceous tumors do not differ very much from those of other parts of the body, but they may be quite painful, especially if they attack persons of a gouty diathesis. They are apt to precede an attack of gout. They are of different size, red and very tender. The plain sebaceous tumors contain a cheesy material, and at times some pus; the rheumatic variety is sometimes filled up with the urate of soda. These tumors are found on all parts of the ear, and their removal is quite easy.

3. Malignant tumors of the ear are of rare occurrence. Epithelioma begins usually as a little wart, which may have been noticed for years without ever having given the slightest trouble, when upon the slightest exciting cause, such as exposure, rubbing the ear, or a lowering of the general health of the patient, this papule becomes itchy and even painful, and breaks down, forming an ulcer with thick papular margins. Removal of the affected portion of the ear is the only remedy for this trouble, which should be done as early as possible. Sarcoma of the auricle is very rare.

4. Vascular tumors of the auricle. *Othæmatomata* are peculiar effusions of blood in the anterior portion of the pinna; they may be traumatic, caused by frequent blows on the ear; they are rare, but seem to have been of more frequent occurrence amongst the ancient Greeks than they are with us. They used to be looked upon as a sign of prowess, and their great heroes are sometimes represented with these tumors of the ear. As idiopathic affections they are also seen amongst the insane, and have in such a case their origin probably in the long-continued hyperæmic conditions of the blood-vessels. They are preceded by red, swollen auricles. The tumors may fill the depressions of the pinna and vary in size from a bean to a hen's egg. The treatment of these tumors is only surgical; they will sometimes rupture spontaneously or become gradually absorbed, but they may be relieved either by opening them and removing the blood-clot and applying pressure afterwards, or they may be treated by hypodermic injections of persulphate of iron or carbolic acid. Erectile tumors or vascular nævi may be removed by electrolysis or by the actual cautery; puncturing them with needles, heated to a white heat, will often destroy them.

3. *Cutaneous diseases of the auricle.*—The pinna is covered with integument and is apt to be attacked by many varieties of skin diseases—Erythema or erysipelas, and herpes zoster auricularis are sometimes seen in this region, but the most frequent of all of these affections is eczema. It is seen most frequently in children, and the favorite seat of the disease is behind the auricle or in the neighborhood of the tragus; but it will occur also frequently in other portions of the pinna. It is sometimes seen in adults, but they are apt to suffer from a dry sub-acute variety, whilst in children we have the moist and more acute variety. The principal cause of the affection is malnutrition and bad air, to a lowering of the system and disturbed digestion. It is apt to show itself after a liberal indulgence in cake and candy, after an irregular mode of eating, especially if the children are allowed to eat all day, or also if they live only on tea and bread and cakes. It is also seen after measles or scarlatina; but it is doubtful whether in these cases it is due to the confinement in badly ventilated rooms or to the debilitating effect of the disease. It is also frequently seen at the time of dentition; or its development is greatly favored by a discharge from the middle ear. In many of these cases of eczema the external auditory canal is entirely free of the disease; but sometimes the trouble will extend up to the membrana tympani. The canal is in such cases red and swollen, is covered with crusts and may be filled with accumulations of epithelial cells; the membrane itself is thickened and hearing is more or less impaired. The disease of the auricle is generally moist, and is accompanied by local heat and redness; the small vesicles, which form in the beginning of the disease, rupture early, either spontaneously or by being torn open by the little patient; the sores become covered with thick crusts, and as the child is inclined to scratch these patches constantly, they are apt to spread rapidly until the whole auricle is covered with yellow or brownish crusts, and there is frequently an abundant secretion of serous fluid. Other parts of the head are apt to show more or less developed eczematous patches. In very rare instances the disease may be confined entirely to the auditory canal; this is generally of the dry variety. The disease, if promptly attended to, will disappear in a few days, provided the patient's parents are willing and able to keep the parts clean and attend to the general hygiene of the child. Cleanliness and fresh air will cure most of these cases in a short time. The child's diet should be good, but especially regular; nothing whatever should be taken between meal-times, not even milk. A warm bath and careful

removal of the crusts prove of great help in the treatment of eczema. For the treatment of the affections, if extending into the auditory canal, a mild astringent lotion may be used. ℞. Zinci sulphatis, gr. v; morphiæ sulph. gr. ij; aquæ, ℥i. S.—Heat gently and apply five drops to the ear, three times a day. The ear should be syringed with warm water, before the drops are applied. Internally the mistura rhei et sodæ (see page 29) with Fowler's solution of arsenic will be of service. A large teaspoonful for adults and half a teaspoonful for children, should be taken twice or three times a day, according to the age of the patient. For eczema of the auricle a local application of the red oxide of mercury ointment with morphia (see page 30) is of the greatest service in acute, and equal parts of the oil of cade and glycerine, to be applied twice a day, in chronic cases or in the dry variety, will have to be used. It is absolutely necessary that the parts should be cleaned and carefully dried before an application of the ointment is made. In cases of very moist eczema a powder of equal parts of bismuth, camphor and starch should be dusted over the diseased parts.

Frost-bites are of frequent occurrence in cold climates. The greatest care should be used to thaw the frost-bitten portion very gradually. If blisters or painful redness follow, the free use of collodion, painted over the parts three or four times a day, will give immediate relief.

4. *Injuries of the auricle.*—On account of the irregular shape and great mobility of the parts, a cut or a tear of the auricle should be carefully sewed up, and not be brought together by plaster only, because this might lead to a great deformity of the ear; after the injury or after the operation a firm-pressure bandage will be found to relieve or prevent any great swelling of the parts and favor union by first intension.

b. Affections of the external auditory canal.—In connection with this canal we have to deal with—1, *foreign bodies;* 2, *inspissated cerumen;* 3, *diffuse inflammation;* 4, *circumscribed inflammation;* 5, *eczema;* 6, *fungous growths;* 7, *polypi;* 8, *exostoses.*

1. *Foreign bodies* of all descriptions are apt to get into the ear, and especially children will succeed to accomplish almost impossible things in this direction; marbles, buttons, beans—in fact everything they can get into the ear, we shall be called upon to extract. But even larvæ and insects are sometimes found here; they are generally attracted by the odor of a discharge from the middle ear, and in summer it is of frequent occurrence to find flies

or larvæ in the ear; they may get there also accidentally and cause often intense pain by their presence. Insects and larvæ may, as a rule, be easily removed by injections of warm water and castile soap; but if it is difficult to dislodge them, the ear should be held over an open chloroform bottle, so that the chloroform vapors may kill the insect, which is now easily removed with the syringe and water. The ear may also be filled with sweet oil and kept upwards, when the insect will soon come to the surface. In regard to the removal of other foreign bodies, the principal rule should be not to use instruments for this purpose, unless all other means have failed. In nearly all cases the object can be accomplished by means of the ear-syringe and hot water; in fact the principal source of danger of such accidents is the temptation to use all sorts of instruments. Another important rule is to make a careful examination with the otoscope to see where the foreign body is lodged and what the shape of it is; it is difficult to remove a thing that you cannot see. If the syringe does not succeed in dislodging the foreign body, and if there is much irritation and swelling of the canal (often due to the attempts at removal), it will be advisable to order some simple soothing remedy, such as a little oil of sweet almonds, and to wait until the swelling subsides, when the foreign body may be easily removed by means of the syringe. If a pea or a bean becomes lodged in the ear, syringing with hot water may be the cause of great pain, on account of the swelling these substances will undergo; they should therefore be removed with the aid of instruments or by syringing with oil; a very fine toothed bent or straight pair of forceps may be used for this purpose. I have often seen the drumhead entirely destroyed by efforts to remove foreign bodies or inspissated wax by means of hair-pins or scissors. In using the syringe for this purpose it is necessary to use it with some force and to lift up the auricle so as to straighten the canal as thoroughly as possible.

2. *Impacted cerumen.*—The function of the cerumen is to soften and protect the lining membrane of the external auditory canal. It is of a very sharp, bitter taste and strong odor, and serves probably also to prevent the entrance of insects to the deeper parts of the canal. The ear-wax consists especially of fat, usually saponified, of some coloring matter, water and organic substances, which are principally hairs and epithelial cells of the auditory canal. The ear-wax is not only composed of the secretions of the ceruminous glands, but also of that of the other glandular organs of the lining membrane of the canal. Abnor-

mality of the secretion may result in a decrease or increase of the quantity and also in a change of the quality of it.

Inspissated cerumen or hardened ear-wax.—The cerumen in the normal condition is soft and evaporates rapidly, but if from some chronic disease of the middle ear or from some other irritating cause, for instance the presence of a foreign body, there is more or less congestion of the auditory canal, the ceruminous glands become affected and their secretion is changed and superabundant and may act as a foreign body in the ear. Under these circumstances the ear-wax is of a dark or light-brown color and is apt to accumulate in large masses, which eventually become very hard and dark; but as they increase only slowly, the canal may in course of time become entirely filled up, without affecting the hearing to a great extent. If the ear is in this state, and the patient jumps or gets thoroughly shaken in a wagon, the hardened mass may be partially dislodged and become firmly impacted, pressing at times against the membrana tympani. This is at once followed by a number of symptoms quite characteristic of the condition; these are: 1, *sudden impairment of hearing;* 2, *tinnitus aurium;* 3, *vertigo;* 4, *pain.*

If a patient comes to us with these symptoms, especially mentioning sudden deafness, fulness and noise in the head, dizziness and sometimes pain, we may expect to find inspissated cerumen in the ear. The membrana tympani is usually not visible and the cerumen is in these cases dark brown and can be easily seen by means of the otoscope; it fills the entire calibre of the canal, generally the innermost portion of it, and may press on the drumhead. If such a dark brown mass is seen in the ear, the syringe and warm water should at once be used. The wax may, however, be so hard that but little, if any, is removed at the first sitting; if it is necessary to remove all the wax at one visit of the patient, a Bowman's probe may be used to break up the hardened anterior portion; but great care should be taken not to push the probe too far into the ear. After this the syringe will easily remove the rest of the cerumen. It is sometimes surprising to see what a quantity of wax can accumulate in the canal.

In children we find at times the cavity of the canal almost entirely filled with soft wax of a light yellow color; this never gives rise, however, to any unpleasant symptoms like the dark brown masses that we have been speaking of. It does not interfere with the hearing of the person at all and is easily removed.

If the inspissated wax is very hard, it may be advisable to use a mild and warm solution of biborate of soda, or of bicarbonate of soda, five grains to one ounce of water; five drops of it are to be applied to the ear mornings and evenings. This will generally soften the wax sufficiently so that it can be easily removed at the next visit of the patient.

Pain is not always present in these cases, but it may be very severe at times; this depends upon the pressure which the mass exerts on the membrana tympani.

If the causes of the irritation remain at work, it may recur many times. It is probable that sometimes the irritation of the canal is kept up by the means employed to cleanse it, such as the corner of a towel, a hair-pin or an instrument called the aurilave.

After removal of the hardened mass the membrana tympani may appear red and congested, and even slight ulcerations of the canal, caused by the pressure of the cerumen, may be seen; but as a rule hearing will be restored and the irritation will quickly subside. If, however, the hearing of the patient is not much improved, we should carefully look for disease of the middle ear. It is always good to apply a little cotton to the ear after removing the cerumen.

3. *Otitis externa. Diffuse inflammation of the external auditory canal.*—This is of rarer occurrence than was formerly supposed, when an examination of the deeper parts of the canal was not so easy as it is now. In nearly all the cases where we have a discharge from the meatus, the seat of the trouble is in the cavity of the middle ear, and the congested and swollen state of the integument of the auditory canal is only secondary and is in many cases caused by the presence of an irritating discharge from this part. Idiopathically it is sometimes seen as the result of cold and exposure, for instance after bathing in cold water; it is more apt to be caused by local irritants dropped into the ear, such as "Harlem oil," and it may be set up by picking the ear with a hair-pin or by cleaning the ear with the corner of a towel, and is generally present in cases where irregular masses of inspissated wax are found in the canal.

Symptoms.—This affection varies greatly in intensity; there may be in some of these cases a slight discharge, which is, however, more serous than purulent. In very mild cases there is only an itchy sensation in the canal, a sensation of fulness and sometimes, especially if the outer portion of the membrana tympani is also affected, impairment of hearing; there is also frequently tenderness of the glands in front and under the auricle. In severer cases, where the subcutaneous tissue participates, there may be severe pain and difficulty in moving the lower jaw, great impairment of hearing and very annoying tinnitus. The skin and the subcutaneous tissue in the canal are very thin, and the affection, if severe, resembles almost a periostitis. But as a rule intense pain is more apt to be found in the localized form of the disease; a diffuse inflammation is usually more superficial and less painful, and especially the secondary form is milder than an idiopathic attack. An otoscopic examination will reveal the following condition: the canal looks red, the integument is swollen, so that the introduction of the speculum may be painful, and the calibre of the canal is considerably narrowed. There may be seen at different parts of the lining membrane slight ulcerations and excoriations, which give rise to a scanty discharge. The membrana tympani may be but little changed, but in some cases there is more or less congestion of the drumhead to be seen, and the light spot may have entirely disappeared.

Treatment.—The treatment should consist, especially in acute cases, in the use of two or three leeches applied to the inner, or if the leeches cannot be made to bite here, at the outer, basal portion of the tragus, or in front of the ear. In many cases a small cylinder of the artificial leech may be applied in front of the tragus with great relief to the patient. In all cases where leeches are applied in the neighborhood of the ear, it is absolutely necessary to close the meatus by means of cotton and to have the parts previously well cleaned with soap and warm water; but even then it may be found extremely difficult to make the leeches bite anywhere near the ear. The sharp odor and taste of the cerumen seems to offer but little inducement to these capricious animals; besides, the local applications that may have been made previously, may have saturated the integument to such an extent that the odor of it cannot be removed by washing. In many cases, however, a slight incision in the integument, causing the flow of a few drops of blood, will make the leeches bite. After their removal, applications of warm water should be made to the parts for one or two hours, to favor bleeding from the bites. But in many cases the use of the artificial leech will be found to be more convenient. Leeches may also be applied behind the ear, but the effect is not so prompt as if they can be made to bite near the tragus. Warmth, dry as well as moist, is of great service; it may be used in the shape of heated cotton batting, or better, by means of a bag filled with heated hops and camphor, which is tied to the ear, or in the shape of poultices or a warm douche. The application of the latter does not consist in syring

ing the ear with warm water, but in letting a constant stream of this run through the canal; a fountain syringe is perhaps the most convenient one for this purpose. According to the height at which this is held the force of the current can be easily regulated. In the early stages of the disease a mild astringent, such as: ℞. Biborate of soda, gr. v; sulph. of morphia, gr. ii; water, ℥ss. M. S.—Five drops mixed with half a teaspoonful of warm water, to be poured into the ear and kept there for ten minutes; this will give great relief and may be repeated every two or three hours. If the pain is very severe, ten drops of Magendie's solution may be dropped into the ear of adults. If suppuration has been established, the little ulcerated spots should be touched with a ten-grain solution of nitrate of silver, or a little dry iodoform may be applied to the parts. The disease may last only a few days if seen early, but it may become very tedious if neglected or maltreated.

4. *Circumscribed inflammation of the auditory canal.*—This is due to a follicular abscess or a furuncle in the subcutaneous tissue of the lining membrane of the ear, especially in the outer portion of the canal. As this tissue is in close proximity to the bone and as the integument of the canal is tense, there is but little room for an inflammatory swelling; the disease will therefore cause the most intense pain, keeping the patients suffering for days and nights. The pain can only be slightly relieved by anodynes. Small and superficial abscesses may be accompanied with only little pain. There is usually great swelling and intense congestion of the part, a throbbing sensation of the arteries, and the canal may be entirely closed, so that the hearing in this ear is much affected, and in bad cases the deafness is almost complete. This may make the differential diagnosis between such an abscess and a disease of the middle ear quite difficult, because in acute cases of catarrhal otitis media, there is also painful congestion and swelling of the external auditory canal. In a localized abscess the pain is apt to be more limited, and we have the constitutional symptoms, chills and high fever, more developed. The integument of the ear is so sensitive that an introduction of the speculum must not be thought of, and there is but little tinnitus in these affections, which in diseases of the middle ear is generally a very prominent symptom.

The cause of such an abscess may be a local irritation, but it is generally to be found in a lowered state of the system. It is liable to come on after a season of hard work, and is more apt to be met with in spring than at any other time of the year. The treatment in the beginning of the affection should be slightly antiphlogistic. Leeches to the tragus and a mild aperient will do good, but the best plan is to make an early incision into the infiltrated portion and apply warm water or poultices afterwards. The seat of the furuncular abscess can be found by the great sensitiveness of the part when a probe is passed over it. The incision should be made, whether there is pus formed already or not, with a short pointed bistoury or a narrow cataract-knife, and must be deep and extensive, and followed by the use of a warm douche. A small conical-shaped onion is a popular and sometimes quite effective remedy to ease the pain; this is also soothed by glycerine or sweet oil, or by dropping five to ten drops of Magendie's solution of morphia into the ear. Holding the ear over a bottle partly filled with chloroform, or better, one containing cotton saturated with chloroform, so that the vapors of it will get into the ear, is very often followed by great relief. A general tonic treatment, the use of the syrup of the phosphate of iron, quinine and strychnine, or of Fowler's solution of arsenic, are of the greatest service to prevent returns of the affection, which are apt to follow one another in quick succession for some time.

5. *Eczema of the auditory canal.*—This has been spoken of before, (page 375). The most unpleasant complication of this affection is the extension of the disease to the drumhead, where it causes the most annoying itching imaginable; it may also result in thickening of the membrane and be followed by great impairment of hearing. The treatment of the affection should therefore be energetic from the beginning, in order to check it before it extends to the membrana tympani. Arsenic should be given early in doses of five to fifteen drops of Fowler's solution three times a day; it may be combined with the mistura rhei et sodæ (page 29) if the digestion is at fault. Great cleanliness of the parts and the use of a mild astringent, combined with an anodyne, to relief the itchy sensation (see page 376), will be found to give immediate relief. Later, in order to improve the dry, hard condition in which the integument of the canal is apt to remain, a mild preparation of the glycerite of tar, or a mixture of one part of oil of cade and three parts of glycerine may be applied to the canal by means of a piece of cotton attached to the cotton-holder.

6. *Otitis parasitica.*—A slight inflammatory condition may be due to fungous growths, which are sometimes found in the external auditory canal. They appear as whitish or blackish flakes covering the integument of the canal; they resemble dandruff,

but they are thicker and heavier and may be so abundant that they block up the canal entirely; they adhere to the walls or to the membrana tympani, which is generally the favorite seat of the fungus and which, after the removal of the membranous flakes, is reddened and sore. Under the microscope these masses are seen to be made up of numerous spores and filaments of a small fungus, resembling the mould fungus. There are a number of varieties of these fungi; they belong to the aspergillus class and differ but slightly from each other. The mycelium of the fungus is deeply imbedded in the epithelial layer of the canal. The condition of the integument most favorable to the development of these parasites is generally that after an eczematous attack; but they are also found without any disease of the canal preceding them. The most annoying symptom of this trouble is an itchy sensation and deafness which they produce; but there is also more or less tinnitus and the sensation of fulness and even that of vertigo connected with this trouble. There is generally a good deal of irritation of the canal connected with it, and it may be the cause of the persistency of an eczematous condition.

Treatment.—Removal of the fungus masses does not result in a cure; as long as the mycelium remains undisturbed in the deeper epithelial layers, and the condition for the development of the fungus remaining favorable, it will soon grow again. The best remedy is to keep the canal very clean, because it is the accumulation of inflammatory products that is so favorable to the development of the fungus. Syringing the canal frequently but gently with warm water or a weak solution of the hypochlorite of soda, ten grains to a tumblerful of water, and instillations of absolute alcohol after syringing the ear may be used, or a mild solution of the biborate of soda or of the boracic acid, half a drachm to a small tumbler full of water, is also useful; it will exert a beneficial effect on the inflamed integument of the canal and destroy the mycelium. These fungous growths are probably of more frequent occurrence than is at present supposed; they are apt to be overlooked or mistaken for other affections of the ear.

7. *Polypi of the ear* are generally found in the external auditory canal, even if they take their origin in or are caused by diseases of the middle ear; they are frequently mucous polypi and consist of very loose connective tissue, cells and blood-vessels, and are covered with epithelial cells; they are of the same structure as the exuberant granulations of mucous membrane, but there are also fibrous polypi; these are not as frequently met with

as the first variety and are composed of a dense connective tissue stroma with many connective tissue corpuscles and of numerous spindle-shaped cells; they are covered with several layers of epithelial cells, are tougher than the mucous polypi and do not bleed as easily as these, because they are not near so vascular.

Polypi are generally round in shape and vary considerably in size and location; they may appear as a small mass of granulation tissue at the bottom of the canal or on the membrana tympani, or they may be large and fill the canal so completely, that they may retain a purulent discharge of the middle ear, which can lead to serious disturbances. These large polypi themselves give rise to a very profuse purulent discharge and to severe hemorrhages and thus produce more extensive irritation of the surrounding tissue. A polypus is of red color if it is at the deeper parts of the canal, but if it is very superficial and especially if it projects from the canal, it is pale and also much tougher. These polypi will develop sometimes with great rapidity, and especially after removal they may fill the entire canal again in a short time. The seat and attachment of polypi varies considerably; they are generally due to diseases of the middle ear and take their origin here in this cavity, or they start from granulation tissue, surrounding a perforation of the membrane. They may also take their origin in the external auditory canal, either near the membrane from an extension of the granulations to the external auditory canal, or they may start from any other portion of the canal; they may be due to a perforation of a mastoidal abscess into the canal or accompany necrosis of the bones of the canal, and in rare instances they may owe their origin to an irritation set up by a foreign body. They are usually pedicellated or may be attached by a broad base.

Treatment.—Polypi are to be removed by either operative interference or by the use of caustics and astringents, or by hypodermic injections. The removal of a polypus may be more or less difficult, and it may be necessary to etherize the patient, because large and deep-seated polypoid masses may be very painful to remove. A fibroma may be easily removed by means of a pair of fixation forceps by twisting or tearing it off, especially if its origin is in the canal, but mucous polypi or fibromata attached to the membrana tympani cannot be removed in this way; the latter because it is too dangerous, the first because it would not be successful; the polypus would tear and bleed and grow only the quicker after the operation. If the polypus is very small, it may be easily removed by forceps, but far better by a fine loop of wire attached to a movable piece of iron and a narrow cylinder through which the wire runs. These instruments are called snares; Wilde's, Jarvis' and especially a modification recently made by Ford of this city, are of excellent service in these cases; they are all very easy to work, no harm can be done by them and there is hardly any pain connected with the operation. If the polypus is very large and closes the canal completely, the growth can perhaps not be removed by one operation. The wire is passed around the base of the tumor, a few turns or a little pressure is made and out comes the polypus, without any trouble. The bleeding is generally slight, especially if Jarvis' ecraseur is used, and is easily checked by the use of astringents. If the polypi are near the meatus, they may sometimes be removed by scissors.

Hypodermic injections of acetic acid, but also of persulphate of iron or carbolic acid, will destroy a polypous growth within a few days; care should be taken to disinfect and clean the ear thoroughly during the sloughing process, and a five grain solution of boracic acid should be injected into the ear frequently during the day. Smaller broad-seated polypi, that cannot very well be seized by the snare, may be treated with the stick of nitrate of silver or chromic acid in a very concentrated solution. The latter should also be used to touch the seat of the polypi with after their removal by the snare in order to prevent the development of a new growth. Iodoform, sulphate of zinc or alum, all in a dry powder, dusted over a polypoid mass will frequently cause its disappearance. Flat polypi with a very broad base may, if necessary, be removed by pushing a needle through the base of the mass and passing the wire loop over the point of the needle; if traction is now made a large quantity of the growth may be removed. Sometimes a polypus will become detached spontaneously, but this is rare. After the removal of a large polypus the hearing of a patient is apt to improve greatly, partly on account of the removal of the obstruction to the sound-waves, and perhaps partly on account of the hemorrhage which follows the operation. If the polypus is large it may render the patient nearly deaf. If the hemorrhage from a polypus, or after its removal from the stump, is severe, the ear may be syringed with a mild solution of alum, or it may be plugged with styptic cotton; the latter must not be left in too long as it may cause a dangerous retention of the secretion of the ear.

8. *Diseases of the bones of the external auditory canal.*—This may be a congenital hyperostosis, which may be so large as to

fill almost the entire canal and to interfere greatly with the hearing of the patient, or it may be necrosis of a part of the bone of the canal. This is generally the result of an extension of a disease of the mastoid cells or that of the middle ear alone. There is generally a very abundant and fetid discharge from the ear in such cases, and accompanying this condition are also frequently more or less exuberant granulations of the surrounding tissues. The bone may be discharged spontaneously in a large piece, or oftener broken down and mixed with pus, or it can be removed by means of the syringe and warm water, or with a pair of long, curved forceps. The ear should be syringed in such cases with a mild solution of carbolic acid, and iodoform in powder is to be applied to the parts. The affection is especially apt to occur in scrofulous children.

Hyperostosis may also be the result of an irritation, set up by diseases of the middle ear; the process begins as a chronic periostitis, and this leads to a hypertrophy of the bone, which may become so large that it occludes the canal entirely and may necessitate an operation. Syphilis, gout and rheumatism are sometimes the cause of it. Necrosis is apt to occur in the posterior wall of the bony canal as a result of a disease of the middle ear, which had extended to the mastoid cells, and also to the auditory canal. In this case both sides of the bone may become affected at once, which leads to great disturbance of the nutrition and the bone is apt to suffer and break down. In this way a large portion of the canal may be lost.

CHAPTER XIX.

THE MIDDLE EAR.

General anatomy.—The middle ear is a bony cavity lined with mucous membrane; it is located between the external ear, from which it is separated by the membrana tympani, and the internal ear, from which it is separated by bone and membranes. It is traversed by a chain of bones that connect the external portion, the membrana tympani, with the internal wall at the foramen ovale.

The cavity of the tympanum is irregular in shape, measuring about 10 mm. in the antero-posterior direction, 4 to 6 mm. from the membrana tympani to the internal ear, and is about 6 mm. high. Above the cavity of the middle ear is separated from the cranial cavity by a thin bony septum, which is, however, perforated by numerous blood-vessels, and also congenital fissures may be found here at times. Inflammatory processes of this cavity may therefore extend easily to the brain even without previous destruction of the bone. The floor of the cavity is very narrow and directly over the jugular fossa; posteriorly it is in intimate relation with the mastoid cells, which open here into the cavity of the middle ear by one large irregular aperture and by several smaller openings; anteriorly we have the carotid canal and the Eustachian tube. The latter opens into the cavity and is considered a part of the middle ear; it serves to connect the tympanic cavity, which is full of air, with the cavity of the posterior nares and also with the atmosphere, so that the pressure of the air in the ear can easily change according to the density of the atmosphere. Through the Eustachian tube the mucous membrane, lining the cavity of the middle ear, is connected with that of the nose and throat, and it is from here that disease is most apt to invade the middle ear.

The outer wall presents, besides the membrana tympani, openings for the chorda tympani nerve and the Glasserian fissure. The inner wall, separating the middle and internal ear, looks directly outwards; on its tympanic surface we notice two foramina and three elevations: 1. The oval foramen; it leads into the vestibule and is closed by a lining membrane; it is occupied by the base of the stapes, the innermost bone of the chain of ossicles spoken of before. 2. The round window or fenestra rotunda; it is posterior to the fenestra ovalis and is separated from it by a round eminence formed by a turn of the cochlea, called the promontory. This foramen is also closed by a membrane, which is sometimes called the membrana tympani secundaria. The elevations found on this wall are: 3. The promontory, which has just been mentioned. 4. The rounded eminence of the aquæductus Fallopii, the bony canal for the passage of the facial nerve; it forms a curve extending from the upper to the posterior portion of the wall. 5. The pyramid; this is a conical eminence situated immediately behind the fenestra ovalis and in front of the aquæductus Fallopii; it is hollow and contains the stapedius muscle, the tendon of which passes through a small opening at the apex.

The ossicula of the middle ear are: 1, the malleus, 2, the incus, and 3, the stapes. The malleus is connected with the membrana tympani, and the stapes with the fenestra ovalis, and the incus connects these two, so that a chain of ossicles is formed with the membrana tympani at the outer and the fenestra ovalis at the inner end. The *malleus* (hammer) presents a head, a neck, and three processes; the long one, called the manubrium (handle), is attached to the drumhead and appears as a whitish line on the membrane, extending from the upper portion of it to its centre; the short process is likewise attached to the middle layer of the upper portion of the drumhead, and the processus gracilis projects into the Glasserian fissure. The head articulates with the next bone, the incus (anvil), by means of a ball and socket joint, allowing free motion for the malleus. The *incùs* consists of a broad head and two processes. The short one projects backwards, and is attached to the margin of the opening of the mastoid cells; the long process descends behind the manubrium and may be seen through the membrana tympani, if very good illumination can be had; it articulates with the head of the *stapes* (stirrup). This bone presents a head, neck, crura and base. The latter rests in the fenestra ovalis and is intimately connected with the vestibule.

The ossicula of the ear are all covered with periosteum and mucous membrane, and catarrhal inflammations of the middle ear, if they extend to this portion of the mucous membrane, may result in anchylosis of the articulations of the ossicles. These bones are all connected with each other and the surrounding portions of the middle ear by means of ligaments and are moved by several muscles. These are: 1, the Tensor tympani, which arises from the upper wall of the Eustachian tube, winds as a tendinous band around the processus cochleaformis and is inserted at the base oı the manubrium of the malleus. 2. The Laxator tympani; this arises from the sphenoid bone and is inserted into the neck of the malleus, and 3, the stapidius muscle, which, as has been mentioned before, takes its origin from the interior of the pyramid and is inserted into the neck of the stapes. The first of these muscles draws the drumhead inwards, thus increasing its tension; the laxator draws the malleus outwards and thus relaxes the drumhead. The stapidius compresses the contents of the vestibule.

The Eustachian tube opens into the cavity of the middle ear at the anterior wall, near the roof of the cavity; it descends in a slanting direction to the pharynx, where it opens into the posterior nasal space a little above the floor of the nostril. The tube is about 35 mm. long and consists of a short bony and a larger cartilaginous portion, which are united by jagged edges. This is called the isthmus and is the narrowest part of the tube. The Eustachian tube is lined with mucous membrane which has ciliated epithelium; it opens during the act of swallowing, and air can be easily forced into the tube at this moment from the cavity of the nose.

The mastoid cells open into the middle ear at its posterior portion, by one large and several smaller openings; the cells are numerous; one of them, much larger than the rest, occupies the upper portion and is called the mastoid antrum; this as well as the rest of the cells are lined by mucous membrane which is continuous with that of the middle ear. The outer shell of bone surrounding the cells is thin, but very hard.

The blood-supply of the tympanum is very abundant and is derived from five different sources; there are branches from the internal maxillary and the posterior auricular artery, and small branches from the middle meningeal, the ascending pharyngeal and the internal carotid artery. The veins accompany the arteries and empty into the middle meningeal and into the pharyngeal vein. The nerves are also abundant; they are those supplying the muscles, the mucous membrane and connecting branches; of these the chorda tympani and the tympanic branch of the glosso-pharyngeal are the most important.

The membrana tympani is of such great importance in diseased conditions of the ear that I shall give here a brief description of it. It is placed at the bottom of the external auditory canal in a slanting direction, forming almost a continuation of the posterior wall of the canal. It is nearly oval in form and about as thick as fine writing paper (0,1 mm.) Its circumference is contained in a groove at the inner end of the meatus. It is composed of three different layers; the inner one is a continuation of the lining membrane of the ear and is therefore mucous membrane; the middle one is a fibrous layer, composed especially of radiating and also of circular fibres. The latter are mostly at the peripheral portion; some of these fibres are elastic. To this layer one of the ossicles of the ear is attached by firm fibrous bands. It is the handle of the malleus; it runs along the inner surface of the membrane, from the upper portion in a downward and backward direction to the centre of the membrane. Along the handle of the malleus most of the blood-vessels of the membrane descend, and in congestion of the drumhead (Fig. xl) they appear, if seen by the otoscope, as a leash of bright red vessels. The outer layer of the membrane is a continuation of the integument of the auditory canal and forms a delicate layer of epithelial cells. The outer as well as the inner layer has its own blood-vessels; those of the outer layer are derived from branches of the deep auricular artery, which enters the ear near the base of the tragus. Those of the inner layer come from the tympanum; these anastomose freely in the inner layer, and on this account, if blood is taken at the tragus, it will influence the circulation of the middle ear. There are also nerves in each layer; the outer contains nerves from the fifth and the inner one branches from the tympanic plexus.

The membrane (Fig. xxxix) is more or less tense and may spot which is a part of the cartilaginous structure at the end of the handle.

Here begins also the apex of the cone or pyramid of light, the base of which lies on the periphery of the membrane. It is called the "light spot" and is triangular in shape. The more funnel-shaped the membrane the larger will be this cone, and in a sunken-in drumhead it is usually quite large. (Fig. xlii) The more central portion of the membrane, behind the apex of the cone and the manubrium, is generally quite dark and is called the *umbo* (shadow).

In diseased conditions of the middle ear the membrane undergoes great changes; it does not only become congested, (Fig. xl) it may be perforated (Figs. xliii and xliv) or entirely destroyed (Fig. xlvi) or it may be covered with granulations (Fig. xli). Independently it is hardly ever inflamed (*myringitis*), but as a secondary process it is very frequently affected. Small hemorrhages may take place in the structure of the membrane; these have been noticed sometimes after violent inflations of the middle ear. Superficial ulceration of the cutaneous layer of the membrane has been noticed, sometimes after the removal of inspissated wax, which by its pressure on the membrane caused slight ulcerations of it. They heal generally in a short time after the removal of the cause without treatment; if they are slow and obstinate, the use of a solution of nitrate of silver or a little powdered Iodoform is indicated. Perforation of the membrane is generally the result of disease of the middle ear (see page 407), it occurs most frequently in the anterior portion of the drumhead, that of Shrapnell's membrane is very rare. Rupture of the membrane is also of frequent occurrence; it is generally the result of an injury. They are as a rule of no great clinical importance, and heal frequently if left alone, but if the ear is inflated and irritating applications are made, they are prevented from healing, cause great impairment of hearing and may indirectly lead to an inflammation of the middle ear. Among the injuries most liable to result in rupture of the drumhead are boxing the ears, the blow of a wave, while bathing in the surf, direct injuries by penetrating objects and falls, especially those associated with fracture of the base of the skull; it is also found in persons who have been executed by hanging, and it may be caused by sudden changes of pressure of the atmosphere; for instance in workmen employed in caissons under water it has occurred frequently. The treatment of a rupture of the drumhead must consist in perfect quiet; nothing should be done for it in the way of medication or surgical interference. There is generally noise and hardness of hearing accompanying the injury, but this must not induce us to inflate the ear, as this might make the rupture much larger. A rupture differs greatly in shape, size and the general condition of the rest of the drumhead from an old perforation, the result of a diseased condition of the middle ear; the latter is more or less rounded in shape; the membrane is often thickened or covered with granulations; if there is only a rupture of the membrane, there may be slight congestion, but no great changes of the rest of the drumhead, and the opening is more of the shape of a rent or a fissure. Hearing is generally restored as soon as the rupture heals.

Calcareous deposits in the membrana tympani (Fig. xlv) are of rare occurrence; they may be seen in old gouty subjects.

Fracture of the manubrium may occur in very rare instances. It is due to direct injury to the drum or to violent falls. It is recognized by the peculiar irregular shape of the bone; one piece is displaced and may move more freely when the ear is inflated, or it may ride over the other end of the bone.

DISEASES OF THE MIDDLE EAR.

The cavity of the middle ear is lined with mucous membrane, and the affections of this organ are therefore all of a catarrhal form and are in the great majority of cases due to an extension of a similar affection of the mucous membrane of the throat.

According to the nature of these inflammatory processes we have to speak of:

1. ACUTE CATARRHAL INFLAMMATION OF THE MIDDLE EAR;
2. SUBACUTE CATARRHAL INFLAMMATION;
3. CHRONIC NON-SUPPURATIVE INFLAMMATION

These may be: a, *Catarrhal.*
b, *Proliferous.*

4. ACUTE SUPPURATIVE INFLAMMATION;
5. CHRONIC SUPPURATIVE INFLAMMATION;
6. SEQUELÆ OF CHRONIC SUPPURATIVE OTITIS.

They are: a, *Polypi.*
b, *Exostoses.*
c, *Mastoid disease.*
d, *Caries and necrosis of temporal bone.*
e, *Cerebral abscess.*
f, *Pyæmia.*
g, *Paralysis.*

I. ACUTE CATARRH OF THE MIDDLE EAR.

This is an affection of frequent occurrence. The principal feature of the process is an increase of the secretion, which is especially mucus. This will rapidly accumulate in the narrow bony tympanic cavity and cause, on account of the non-distensibility of and on account of the abundance of nerves in this region, a great amount of suffering. The accumulations in the ear may press on the membrana tympani and cause it to bulge outwards as far as its connection with the ossicles will permit; but it will only in exceptional cases lead to a rupture of the drumhead. The mucus will generally find its way through the Eustachian tubes or it will become absorbed in the latter stages of the disease.

The formation of pus in this affection may be seen during the later stage of the inflammation which is then oftener accompanied by perforation of the drumhead; but the principal feature of the inflammatory process is the secretion of a thick, viscid mucus. The mucous membrane itself is thickened and congested and the Eustachian tube may be entirely closed. The disease is often accompanied by constitutional symptoms; there is marked fever, and even delirium may be present.

The pain is one of the most prominent symptoms, not only that severe deep seated pain exists, but the surrounding parts of the ear swell and become extremely tender to the touch. Milder cases occurring in the course of a general cold may not be so alarming; the ear-ache, so often complained of by children especially, is generally caused by a process of this kind; it attacks generally one ear, but both ears may be affected at the same time. With this condition there is a sensation of fullness in the ears and only moderate impairment of hearing. It will pass oft in a few days or weeks and leave the ear apparently uninjured.

The disease is however apt to be more serious when there is a rapid increase of the secretion in the ear; in these cases the severe pain, the great deafness and the marked tinnitus demands active treatment; the pain is more of a neuralgic character affecting often the entire side of the head. The Eustachian tubes are always more or less affected and the pain is always increased by any violent motion of the head or mouth; talking, coughing or sneezing, and even the act of swallowing are therefore apt to increase the pain to such an extent, that the patients do not dare to eat or drink for days; especially eructation becomes very painful. In children a so-called ear-cough is often present and depends on irritation of the auditory branch of the pneumo-gastric nerve. The hearing may not only be bad, but there are peculiarities in the hearing; sounds appear hollow or of a higher pitch and become painful to the ear.

In very young children these symptoms will not help us in making our diagnosis; the infants cry out with great pain very suddenly, uttering peculiar shrieks, such as are often heard in severe cholera infantum; they will refuse all food and are very restless all day and especially so at night; the disease may come on in different periodic attacks. A very useful diagnostic sign is to press the ear of the little sufferer, and if this increases the pain and causes the child to cry out loud, or if on the other hand by breathing or dropping warm water into the ear the pain be relieved, there is generally ear-disease present.

The most prominent objective signs are to be found in the membrana tympani: this is red and congested, either entirely at the periphery, or along the manubrium of the malleus only. The increase of the contents of the tympanic cavity causes an early bulging of the membrane, generally as early as the second or third day. It is generally the posterior portion of the drum-head and sometimes Shrapnell's membrane that becomes most prominent. If the tension in the middle ear is very great and especially if it is due to purulent matter, spontaneous rupture is liable to take place; this will result in a discharge of a little fluid and causes great relief from all pain. A perforation may be followed by a speedy cure, but through changes of the weather, or after slight exposure another attack may come on, and it is this liability to relapses which is the source of the greatest danger to the hearing of the patient. One attack is not apt to do much harm, but each added attack will decrease the hearing power of the patient, and thus the disease is apt to cause eventually complete deafness.

Causes of acute aural catarrh.—The disease may take its origin in the tympanic cavity, or it may attack the Eustachian tubes first by an extension of a catarrhal inflammation of the mucous membrane of the throat, and especially the sore throat of the eruptive fevers, also that of syphilis, and frequently a severe cold, causing a sore throat, may be the direct cause of the ear-trouble. In these cases the mouth of the Eustachian tubes is the first part to suffer. Sometimes, if the disease begins in the ear itself, this may be caused by the use of the nasal douche, when water is forced into the ear through the Eustachian tubes, or it may occur when cold water is allowed to run into the ear, while bathing or diving. It may, however, be due to exposure to cold and wet, when ear and throat may become affected simultaneously; it is therefore often seen in the spring or autumn. Another cause is often at work in young children; this is teething. In these cases the disease of the ear is probably due to nerve-irritation. This cause has been observed to lead to acute aural catarrh also in adults; in these cases it is usually due to decaying teeth, or where the mucous membrane of the mouth is irritated from sharp teeth or badly adjusted false teeth.

The principal diagnostic points of the affection are: 1, the peculiar beating and puffing in the ear; 2, the sensation of fullness, caused especially by the closure of the Eustachian tube; 3, the catarrhal nature of accompanying throat-troubles, and 4, as a rule the absence of inflammatory signs of the auricle and the external auditory canal; 5, the pain is apt to come on at regular intervals, and 6, the drumhead, varying in degree of congestion, may be bulging extensively, but is not apt to rupture.

Treatment.—It is of the greatest importance to have this disease carefully attended to, as bad treatment or neglect may lead to suppuration and destruction of the hearing power of the ear. The patient should be treated in severe cases as a very sick person: he ought to remain in bed, or at least in a dry, warm room and should not be exposed to the changes of the weather. Mild saline cathartics and moderate doses of quinine are often of great value in the very beginning of the trouble. Of the local applications heat, either dry or moist, is of the greatest value. If the patient is obliged to be out doors, dry warmth during the day is preferable, and if hot water is used during the day the best plan is to apply this by means of the douche; the ear should be carefully dried and cotton should be used to keep the cold air from entering the auditory canal. Syringing with warm water, if it is not very carefully done, will be very painful; the ear douche or a fountain syringe is far preferable; the friction caused by the current of water is especially agreeable, and it should be applied for several minutes every half-hour. In cases where this is not convenient to use, warm water may be poured into the canal and left here for ten or fifteen minutes. This may be at the same time combined with a mild anodyne; a few drops of laudanum should be mixed with half a teaspoonful of warm water and poured into the ear. An infusion of poppy-heads or of the German chamomile flowers may be used instead. Sometimes a few drops of Magendie's solution of morphia may be dropped into the ear; but it should be carefully used in infants, especially if there is a perforation of the drumhead, as the morphia might get into the throat and poison the child. In adults ten drops may be safely used in the ear. Breathing into the ear, or blowing tobacco smoke into it, will often relieve the pain. The use of leeches to the tragus, in the very early stages especially, gives great relief; the artificial leech may be used instead; this may cut short the attack or greatly modify the course of the disease. Paracentesis of the drumhead should, however, only be resorted to if there is marked bulging of the membrana tympani, which can be easily diagnosticated by means of the speculum and otoscope; or if the pain is severe and cannot be relieved by other simpler means, even if there is no bulging of the membrane, paracentesis of the drumhead may be done by means of a cataract needle. A large speculum is introduced into the ear; the ear mirror fastened to the forehead, and while the ear is well illuminated, the needle is passed along the floor of the auditory canal close up to the membrane, which can now be pierced at any place where its bulging is most prominent. This is followed by a very small amount of bleeding and the escape of a small quantity of mucus; but the relief afforded is, as a rule, very marked. The operation should be followed by inflation of the ear by Politzer's or Valsalva's method, and later, by the warm douche, which aids in the escape of the accumulated matter and prevents the perforation from healing too rapidly. The wound made by the operation is apt to heal within twenty-four hours, and a paracentesis may have to be repeated several times. Care should be taken not to injure the manubrium during the operation; this is easier to avoid by using a needle that is attached to a bent handle, which gives the operator a better chance to see what he is doing.

The use of the catheter or Politzer's method is, as a rule, of excellent use to relieve the pain, but in very acute cases it may be of less value in the beginning on account of the swelling of the lining membrane of the Eustachian tube; its use may also be painful at this period; it is, however, of great help after the acute symptoms have subsided, and hearing is often very promptly restored by it. If the child is too little or is untractable, so that it cannot be made to swallow at a given moment, inflation will often be successful, if done while the child is crying. The force of the inflated air should be very slight in little children, and inflating the ear by the use of a rubber tube, one end of which is introduced into the child's nose, while the surgeon is blowing in the air at the other end of the tube, is in such cases a much better method. Suppuration is avoided in most cases treated in such a manner, but in exceptional cases suppuration and destruction of the membrane may occur early in the disease in spite of our treatment. This is often accompanied by severe hemorrhages from the ruptured membrane, or hemorrhages may take place into the cavity of the middle ear; this variety has been named *Otitis media hemorrhagica.*

II. SUBACUTE CATARRH OF THE MIDDLE EAR.

This variety of ear affections is only a mild form of the acute catarrh. It occurs as a rule in children or young subjects and is more characterized by periods of marked deafness and noises in the ear than by severe pain. It is of frequent occurrence, and is apt to be neglected until it has resulted in great changes of the middle ear.

Symptoms.—Of these the impaired hearing is the most marked; the attacks occur at different periods, and may pass off in a few days without apparent change in the hearing of the patient, but they will become more frequent and of longer duration, frequently interfering with the study of the patient. The disease is apt to show itself after a slight cold, but the general health of the patient seems to have nothing to do with it; it attacks strong as well as delicate persons. If a child is examined at such a period, we shall find the pharynx in an inflamed condition; the mucous membrane is congested, thick, and its follicles are swollen, which gives it a granular appearance; the normal secretion is greatly increased. The drumhead is of a decided pinkish hue, but the vessels of it are not marked; the light spot is frequently absent and the hearing is much impaired. This is a condition of deafness, that is generally attributed to carelessness and inattention of the child, but which is really due to a diseased state of the middle ear.

Treatment.—As the future happiness of young persons may depend upon the victory over this assiduous enemy of the ear, a condition, such as has just been described, requires the same careful treatment as any serious disease of other parts of the body, and this should be begun in the early part of the affection and not until it is too late. There is a popular idea that a trouble like this is outgrown, and this does happen in a certain number of cases, but in many others it is followed by such an amount of deafness that the patients become entirely unfit for ordinary business pursuits. In regard to the treatment it must be said, that the hygienic part of it is fully as important as the therapeutical. Such children ought to have regular meals, simple but nutritious food, no cakes or candy or pastry—in fact, nothing should be taken between meals. The use of flannels is in our latitude and changeable climate very necessary. In delicate and scrofulous children tonics and especially the syrup of the iodide of iron, should be used. The local treatment should be directed to the throat: an application of persulphate of iron one part and glycerine three parts should be applied to the pharynx, especially if there is much thickening of the mucous membrane; during the period of teething, from the sixth to the twelfth year, loose or decaying teeth or other oral irritations should be promptly removed. If there is much posterior nasal catarrh, spraying the nasal cavity, especially the posterior nares, with a solution composed of nitrate of silver five grains, glycerite of tar half an ounce, and water three ounces, will be of great service; its effect on the mouths of the Eustachian tubes is of special value, because in many of these cases the whole trouble may be located at this point. One of the greatest means of relief is, however, inflation of the middle ear by Politzer's method. This will cause almost immediate relief; it should be used every other day until the hearing is improved. In younger children the use of the tube is perhaps better (see page 396). If possible, the Eustachian catheter should be employed for this purpose if only one ear is affected.

III. CHRONIC CATARRHAL INFLAMMATION.

Chronic non-suppurative inflammation of the middle ear is one of the most frequent and unfortunately also one of the most untractable diseases that we are ever called upon to treat. This is partly due to their insiduous mode of attacking the patient, who hardly imagines that there is anything wrong about his ears, when they are perhaps changed to such an extent that a cure has already become a matter of impossibility; another reason why the disease proves so obstinate to treatment is the fact, that we cannot get access to the seat of the inflammation, the membrana tympani being not only without a perforation, but on the contrary thickened to such an extent that no medication could possibly change it, much less affect the parts lying behind it. According to the pathological condition of the middle ear, affections of this kind may be divided into two classes, (*a*) catarrhal and (*b*) proliferous, and although a distinct line between the two cannot be drawn; the main lesions of the first or latter will usually predominate in different cases. The principal feature of the catarrhal variety consists in the formation of cicatricial changes of the mucous membrane; that of the other variety in proliferation and hypertrophy of it.

a. Chronic catarrhal inflammation.—A patient may suffer for a long time from a chronic catarrh of the posterior nares or the throat without having the slightest warning that the disease is progressing in a direction least suspected by him, namely to the ear. There is generally great fear manifested by the patient, lest the affection might go down to the lungs, and it rarely occurs to him that there is more immediate danger of the affection "going up to the ear," and even slight earlier symptoms of an implication of the ear are often attributed to slight irritations due to exposure, if they are noticed at all. These early symptoms are: 1. A sense of fulness of the ear, which is apt to become more manifest during certain conditions of the atmosphere. 2. Sounds like the crackling of air bubbles in the ear; these are apt to be heard especially during the act of deglutition or even during mastication. 3. The impairment of hearing manifests itself in such manner, that everything sounds to them as if it had been spoken in an undertone; but as their own voice sounds to them even more distinctly than before, they are apt to speak in a very low tone themselves. Gradually other symptoms begin to manifest themselves, which may be attributed to other troubles, but still are apt to make the patient cognizant of the fact that the ear is the source of the trouble. 4. There is at times a marked sense of fulness in the ear: the patient suspects perhaps that there is inspissated wax. 5. Tinnitus aurium becomes later a very prominent and distressing symptom. The noises which these patients hear are varying; some describe them as a rushing of waters, others complain about a constant ringing of bells near their ears, in others it has the sensation of a throbbing or of a constant buzzing in the ear. This, continuing from morn until night for weeks, months, or even years, has a very depressing influence on the patient. Tinnitus has led to insanity and suicide, and no matter what the patient does, he cannot escape from this very annoying enemy to his comfort.

6. Vertigo is also sometimes complained of, although it is not a constant symptom of catarrhal inflammations. If the other ear-symptoms are not very marked, it might be looked upon as a sign of a cerebral affection.

7. The catarrhal symptoms of the throat may during this time be very manifest without the patient suspecting any connection existing between the two affections. In our charitable institutions these patients are often in the habit of visiting the throat

department as regularly as the aural department, even if they have not been told that one trouble depends upon the other, and that no permanent relief can be obtained for the ear unless the pharyngeal catarrh is improved.

Objective symptoms of chronic catarrhal inflammation are, in the first place, impairment of hearing. This symptom, as has been mentioned before, varies greatly in extent, and the affection may result even in complete deafness. The hearing should be measured carefully by the watch as well as by the ability to hear conversation. A peculiarity often observed in these patients is, that they hear better in noisy places than where everything is perfectly quiet; they hear even better under these circumstances than persons with normal hearing; but the tick of a watch, which of course remains always the same, is heard no better than under ordinary circumstances. This may be explained by the fact that these persons do not perceive sound-waves unless they are very distinct; that they do not hear the confusing noise made, for instance, by the rattling of a stage; but any sound which is more distinct and louder than this noise is heard more distinctly, because the latter is not heard at all. In regard to the deafness of the patient, the tuning-fork offers us a very reliable means of diagnosis, whether the cause of it is an affection of the middle or some lesion of the internal ear, because it is heard distinctly in an ear affected with catarrhal inflammation, but not at all in one deaf from affections of the auditory nerve. For the same reasons given above, such an ear, which does not hear the confusing noises of the street, perceives the vibrations of the tuning-fork by bone-transmission more distinctly than the normal ear does. If both ears are affected with catarrh, the one, whose hearing by ærial transmission is most impaired, will distinguish vibrations more distinctly than the less affected one.

2. The drumhead undergoes certain changes in this form of aural trouble, but they are not of great diagnostic value, as they may not differ materially from conditions met with in perfectly normal ears. Changes in the mobility of the drumhead are not marked; it moves whenever the air is forced into the cavity of the middle ear by a prolonged inspiration and expiration with mouth and nostrils closed. The movements of the membrane may be watched by the observer through the speculum; sometimes the membrane does not move, at other times it moves even more readily than in the normal condition. The greatest change of the drumhead is caused by a sinking of it; it is retracted by the contractions of the lining membrane of the tympanic cavity.

A sinking-in of the drumhead becomes very manifest by the great prominence of the short process of the malleus, which stands out like a knuckle of a finger with the membrane stretched tightly over it. The manubrium is especially drawn inwards, so that in many cases it is barely visible. The light spot undergoes great changes; it is no longer triangular, it is irregular or much smaller and may be entirely absent. Sometimes we notice chalky spots on the membrane in the course of a very chronic affection of this kind, but they are not characteristic of this disease (Fig. xlv.). The membrane may also have lost its lustre and have an opaque appearance.

The Eustachian tubes are frequently obstructed in this disease, so that inflation becomes very difficult or even impossible. If we find that inflation is impossible by means of Valsalva's or Politzer's method, the Eustachian catheter will prove of great service, especially if the obstruction is at the mouth of the tube, which is of frequent occurrence; but we meet with many cases where the obstruction is so great that inflation becomes quite impossible.

The throat may be seen in these cases to be suffering from very extensive changes, due to the long-continued catarrhal inflammation of the parts. Its mucous membrane may be changed entirely into a glossy, cicatricial tissue, or it may be studded in granular pharyngitis by small round elevations. Polypi of the nose or enlarged inferior turbinated bones may also serve to compress the mouth of the Eustachian tube. Nearly all our patients suffering from the catarrhal form of otitis will be aware of their throat trouble, or if not, will admit of accumulations of mucus causing expectoration and hawking.

Treatment.—There is no disease of the ear that requires more perseverance in treatment on behalf of the patient as well as on the physician than a chronic catarrhal affection of the middle ear. It has been said before that in many cases the changes produced by the disease are such, that they cannot be entirely removed and that frequently the patient can only be relieved to a certain extent; or that we have to be satisfied to prevent the disease from causing further mischief, and to save for the patient that amount of hearing which still remains. Attention to the general hygiene of the patient ought to play an important part in our treatment; the patient should be brought into such a condition that he becomes less likely to take cold on the slightest exposure, because each new cold is apt to add to the existing trouble. Diseases that have a tendency to lower the general health of the patient must also receive strict attention; a scrofulous condition of the patient should be corrected by a persevering administration of cod-liver oil and the syrup of the iodide of iron, or of pills of the iodide of iron, if the cod-liver oil is not indicated. Sore throat in all its various phases ought to receive prompt attention. The spray of tar and nitrate of silver (page 398) or the following perscription: ℞. Ammon. hydrochl. gr. v; solut. Magend. gtts. xv; liq. ferri subsulph., glycerine, aa ʒ ii. M. applied to the throat morning and evening will prove of the greatest benefit in chronic affections of the throat. Another preparation of great simplicity, which has done me great service, is a gargle made up of one drachm of ferric alum and one drachm of chlorate of potash to one pint of water. This is to be used twice a day as a gargle, and a few drops of it are to be drawn up through each nostril once a day. The use of the nasal douche may be of service in some cases; but it must be remembered that it is sometimes a source of great danger to the ear, as fluid may get into the tympanum through the Eustachian tube. In such a case, which can sometimes not be prevented, acute inflammation of the middle ear may follow.

Inflation of the middle ear is of the greatest importance in this disease. It should be done either by Politzer's method or by the use of the Eustachian catheter. As inflations have to be continued for some time, and as the patients soon realize the improvement of hearing after the use of the inflation, they are apt to resort to this method without the assistance of the physician. This is a practice which should not be encouraged, because the patients are apt to overdo it, and thus do more harm than good.

The membrana tympani is abnormally movable in many of these cases and may by the injudicious and too frequent inflations become so distended and flaccid, that it will be entirely useless for conducting sounds. Inflation should be practised only every other day, and inflating the ear twice or three times at one sitting is sufficient. In very obstinate cases the inflation of medicated air is of great service. A little air-chamber, connected with the air-bag, which contains cotton saturated with either the tincture of iodine or finely pulverized iodoform, will medicate the air before it is forced into the ear. Steam and sprays of nitrate of silver are sometimes of great help in obstinate cases, but their application is difficult and requires a costly apparatus. Applications made through the external auditory canal cannot do much good, because they cannot reach the seat of the disease; the only thing to do in this way is the use of the warm douche. This is especially of service if an attack of pain and congestion should occur in the course of the disease, which is apt to follow after the slightest exposure. This is the only time when there is pain connected with the disease, which however is speedily relieved by the use of a few leeches or Politzer's air-bag. Paracentesis of the drumhead has been recommended in order to apply remedies to the cavity of the tympanum; this may be done in a manner described in the treatment of acute aural catarrh (page 396); but the results obtained so far have not been as satisfactory as might have been expected and in many cases it has even made the hearing of the patient worse.

b. Chronic proliferous non-suppurative inflammation of the middle ear.—This variety of aural disease is characterized by proliferations of the mucous membrane and great changes in the tympanic cavity; there is frequently anchylosis of the ossicles and also marked change in the structure of the tensor tympani muscle. The Eustachian tubes are obstructed by great thickening of the lining membrane, and it is hard to inflate the tympanic cavity. There is also frequently great thickening of the petrous portion of the temporal bone, and the cavity of the tympanum may be partially obliterated by adhesions of the membrana tympani to the inner wall of the cavity. These changes are brought about by a chronic inflammatory process of the mucous membrane of the middle ear, resulting in extensive adhesions and granular changes in this tissue. Sometimes partial contraction or cicatricial changes may follow this stage of the affection.

This disease is in some respects like the catarrhal form, but it differs from it especially by the freedom from throat complications or acute attacks of pain. It is due more to constitutional affections than to exposure, and is frequently seen in persons of a scrofulous diathesis, or of an inherited specific taint, in phthisis pulmonalis and also sometimes in acquired syphilis; during pregnancy the ear is especially apt to be invaded by this disease. If such predisposed persons commit an error of diet or hygiene, or if the tone of their system is lowered, diseases of this kind are not only apt to develop, but may take such a hold upon the tissues, as to render it next to impossible to get ever entirely rid of them. This form of an aural trouble, started in such a way, will progress steadily, even if the condition of the patient is improved in every other respect. The presence of the disease may in fact not be even suspected until the patient is nearly deaf. The symptoms of this affection are very indistinct in the beginning; later the impaired hearing and especially the most annoying and persistent tinnitus aurium becomes more marked. One of the greatest dangers of the disease is the insidious mode of its attack: it is not preceded by ear-aches, nor by severe or even chronic catarrhal affections of the throat. The hearing gradually becomes worse and worse; sometimes in spite of all our efforts we may not be able to check the progress of the disease, much less effect a cure; especially those cases associated with an inherited scrofulous or syphilitic diathesis are very unpromising ones, and the tinnitus is apt to be of the most persistent kind. The most characteristic objective sign of the disease is a dry, opaque and depressed drumhead, and the tip of the manubrium is especially apt to be greatly thickened. The drumhead may be retracted to such an extent as to be connected with the inner wall of the middle ear; the ossicula are greatly changed and firmly anchylosed.

The treatment of this affection differs but slightly from that of the catarrhal form, only that in the latter the frequency of the throat complication requires careful medication of this organ; in the proliferous forms throat troubles are exceptional.

The constitutional treatment is in this variety even of greater importance than in the first, and iodide of potassium should occupy a prominent place among the remedies used. It should not only be given in the specific cases, acquired as well as inherited, but also in strumous persons its use is often followed by very good results; the potassic iodide may be combined in many cases with a mercurial preparation (see page 170), especially in the acquired syphilitic affections, where the character of the aural trouble has more the appearance of a periostitis; this will be very useful as a part of the general constitutional treatment—baths, especially the Turkish bath without the cold plunge, have been of great service in some cases. Leeches are only called for in cases of acute congestive attacks; they have to be applied sparingly, one at a time will be sufficient. The Eustachian tube is often so completely closed that the obstruction cannot be overcome by Politzer's method nor by the catheter; in these cases the use of Eustachian bougies is of great service. These bougies are made of hard rubber and are very fine; they are to be introduced through the catheter one at a time; as soon as this one is in place another is passed along the first, and in this manner three or four of them may be introduced into the tube at a time. In most cases, however, if the tube is open, pure or medicated air should be frequently forced into the ear. There is hardly any danger in these cases that inflation can be practised too often, and an air-bag may be safely intrusted to the patient for this purpose. By the use of the Eustachian catheter for these inflations a more complete success is obtained; medicated or plain vapor may be made to enter the tympanic cavity by the same means. This is done by interposing between the air-bag and the end piece, which fits into the catheter, a little bottle in which the plain or medicated steam is generated; the steam is from here forced through the tube into the ear. The use of a hard-rubber catheter is in these cases preferable to a silver one, the latter sometimes becoming very much heated. Even fluids may be forced into the ear through the tube. The medicated fluids, intended to reach the middle ear, are placed into the Eustachian catheter and immediately forced into the middle ear, whilst the patient is in the act of swallowing. Attention to a given signal will indicate the exact moment of induced deglutition. These medicated fluids must of course be very diluted. Nitrate of silver, sulphate of zinc, hydrate of chloral, and atropia are most frequently made use of for this purpose. The use of medicated air has been mentioned in the preceding chapter. In very obstinate cases of obstruction of the Eustachian tube the use of chloroform vapors has been found very useful; it should be used very carefully because it is felt very keenly by the patient. One or two drops of chloroform may cause considerable pain when introduced into the tympanic cavity, but the ease with which it passes by Eustachian obstructions has militated against its condemnation. Operative interference in these cases, except paracentesis of the drumhead, is but seldom resorted to, and this is uncertain in its results. Among the other procedures proposed, mention may be made of the insertion of a hard-rubber eyelet into the drumhead, in order to obtain a permanent opening in this membrane; this method may be practised in some cases, but severe irritation, set up by its use, has prevented its universal adoption. Tenotomy of the tensor tympani muscle has also been performed, principally for the relief of the tinnitus aurium.

ACUTE SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR.

This disease is generally preceded by an acute catarrh of the middle ear, which through neglect, but sometimes in spite of our best efforts for its relief, passes into a purulent form. In other cases the disease seems to have a markedly purulent tendency from the beginning. The principal difference between the catarrhal form and this variety of the disease is that in the former there is a great tendency to infiltration and contraction of the tissues, while in the latter the formation of pus cells is the principal feature of the inflammatory action. Acute catarrh of the middle ear is therefore seldom followed by a breaking down of the tissues or an affection of the surrounding parts; in the purulent form sloughs are apt to be met with, the infiltration of the pus cells being so great that the nutrition of the tissues is greatly interfered with and they break down very readily; but also the surrounding tissues are apt to be frequently implicated, and on that account the picture of the disease is a very different one from that of the catarrhal form; in the latter the cavity of the tympanum is almost exclusively the seat of the disease, but in purulent otitis the inflammatory process will extend not only outward into the auditory canal and to the mastoid cells, but it may even invade the brain and thus become a great source of danger.

Symptoms of purulent inflammation.—These are in the beginning like those of a severe catarrhal inflammation, but they soon become aggravated by an extension of the inflammatory process. 1. There is pain, but this is not alone confined to the ear, it affects the whole side of the head and is greatly increased by any movement of the patient, especially during mastication; the patient may not even be able to open his mouth. The slightest touch of the ear will be painful, and a recumbent position seems to increase the pain to such an extent, that the patients will walk the floor for days and nights without sleep, crying and moaning with anguish. The pain is of much longer duration in this form of the disease than in the catarrhal variety; but it is frequently promptly relieved if perforation of the drum takes place, either spontaneously or by an operation. Delirium is often noticed during this stage of the disease. At times the pain may not be so intense, for instance, the symptoms of an otitis following or accompanying scarlatina or measles are often hardly noticeable, though at times they become only too evident.

2. Sometimes a peculiar itchy or tickling sensation is complained of, especially in the beginning of the disease.

3. Tinnitus aurium forms a very annoying and distressing symptom; the patients describe it generally as a puffing or blowing sound. A throbbing sensation in the congested vessels is also very marked.

4. Changes in hearing are generally observed from the very beginning; at this time the ear is apt to be abnormally sensitive and may be even painful to sound-waves, especially is this the case with harsh sounds; even the patient's own voice may intensify the pain. Later, as the disease progresses, the hearing becomes more and more impaired, and if the cavity of the tympanum is filled with pus, the deafness is very marked.

5. Vertigo is often present; it is probably caused by the pressure of the accumulated inflammatory products on the labyrinth.

6. Fever is quite marked in some cases, and especially noticeable is local heat of the affected parts.

Objective symptoms. The looks of the patient will generally indicate the severity of the disease we have to deal with. There is generally some swelling of the external auditory canal, which is more or less congested; also the surrounding integument of the ear is swollen to a considerable extent. The drumhead is affected early in the disease; it is more or less congested, especially the vessels running downwards over the manubrium are enlarged and plainly visible; later the periphery and eventually the entire membrane becomes red and swollen (Fig. xxxix.), so that the manubrium is hardly visible, and the light spot and also the peculiar lustre of the drumhead may have entirely disappeared. As soon as an accumulation of pus takes place in the tympanic cavity, the membrane, having lost much of its power of resistance, begins to bulge outwards; this is especially seen in the lower portion of it. As the disease advances and the collection of pus increases, the bulging of the drumhead becomes more marked, and without surgical interference the drumhead will eventually break down, the result of which will be a perforation. This is apt to take place at a comparatively early period on account of the atonic condition of the membrane, and especially in a very debilitated state of a patient, for instance after a severe disease or in phthisis pulmonalis, the membrane breaks down very easily, even if there is not much pain or severe inflammatory symptoms present in these cases. A perforation of the membrana tympani is generally accompanied by a slight discharge of pus and blood and is usually followed by great relief of pain; in rare cases the pus may be discharged through the Eustachian tube. The opening in the drumhead may close again after a short time, before the inflammatory process had come to a standstill; in this case the pain is apt to become again very violent until another perforation takes place; but the first opening remains often permanent. Such an opening may be round or irregular in shape in the beginning, but later, after it had existed for some time, it is generally round (Fig. xliii.).

After the rupture has taken place, the disease is at once modified and may entirely subside in a few days. The opening in the drumhead will close, indeed very rapidly at times; the membrane itself will remain more or less congested for some time, but it may eventually be restored to its former condition. Again the disease may be relieved of its most pronounced violent symptoms but not subside entirely; it becomes chronic, and the discharge continues through the much enlarged opening. The drumhead itself becomes very much swollen and covered with granulation tissue (see Fig. xlii.).

In other cases the perforation of the drumhead will give only temporary relief and the pain may become severer than it was before; in these cases the pain cannot be chiefly caused by pressure and is probably due to an affection of the deeper parts of the tympanic cavity. The disease may have spread by this time to the mastoid cells, which are now very tender on pressure in the region of the mastoid process, or, in very unfortunate cases, the process may extend through the roof of the middle ear to the brain; this is, however, of less frequent occurrence in acute than in chronic suppurative inflammation.

The causes of this affection are very much like those of an acute catarrhal inflammation; in fact the disease begins frequently as such, but it seems that some constitutions are more prone to purulent inflammations than others, and sometimes no other cause but this can be assigned why the disease took such a malignant course. In other cases the system, weakened by an accompanying disease, seems to have less power of resistance, and not only does pus form in the course of a catarrhal inflammation under such circumstances, but it is apt to form rapidly and in large quantities and is followed by an early perforation of the membrana tympani. We are apt to see such attacks after severe cases of the exanthematous fevers, and in these diseases early examination of the ear and prompt treatment may save the little patient much misery.

Of the effect of cold surf-bathing, especially of diving, on the ear has been spoken of before; it is one of the causes that might be easily avoided by plugging the external auditory canal with cotton before going into the water. Colds and affections of the throat are also frequently the cause of purulent otitis. The throat affection may have been an acute or a chronic one aggravated by a new cold. Sometimes it is caused by direct injuries, or even concussions may lead to it. Oral affections are also apt to set up an otitis.

Differential diagnosis.—In acute catarrhal inflammation the difference in the appearance of the drumhead is great. There is seldom such intense and lasting pain as in the purulent form, in which we have also more marked constitutional symptoms than in the former. In otitis externa the auricle and drumhead are very painful, but an examination of the canal by means of the otoscope will easily reveal the true nature of the affection; this disease is very rare compared with the purulent form. Toothache may often be mistaken for ear-ache or *vice versa*, but touching the teeth with a small piece of metal will generally indicate whether any of the teeth are decayed; but a decayed tooth may lead to a disease of the middle ear.

Treatment.—Acute suppurative inflammation of the middle ear, if neglected, may lead to very grave consequences; but there is hardly any disease of the ear or of other parts of the body of such severity, which can be so promptly relieved if it is early attended to. As this affection is apt to be seen by the attending physician in the very earliest stages, for instance coming on during an attack of measles or scarlatina, it should not be allowed to develop to such an extent as to materially impair the patient's hearing.

Antiphlogistic remedies are of the greatest value in the treatment of the earlier stages of the disease; in children two leeches applied to the tragus will give great relief. If the patient is very debilitated the blood should be checked immediately after the leeches have dropped off. This is easily done by gentle pressure or by applying a small piece of styptic cotton to the leech-bite; in adults the use of the artificial leech may be of greater service than leeches. Cotton should always be packed into the ear if leeches are applied to prevent them from getting into the ear.

One of the most painful complications is the extension of the inflammatory process to the mastoid cells; the mastoid region becomes under these circumstances red, swollen and very painful. In order to relieve this condition, a deep incision should be made through the integument down to the bone, or in children one or two leeches may be applied to this region. The membrana tympani should be carefully watched and if any bulging is seen, or in very severe cases, where the pain cannot be relieved by other remedies, the drumhead may be perforated in a manner indicated on (page 396,) even before any bulging of it becomes manifest. The bulging is generally most prominent in the posterior and lower portion of the drumhead. In order to relieve the acute pain Magendie's solution of morphia, slightly warmed, should be dropped into the ear; ten to fifteen drops may be used at a time for adults, but if perforation has already taken place, morphine should be used with care. Warm applications, especially the ear-douche. is of great service; it should be used about ten minutes at a time every two or three hours.

After perforation has taken place the use of the douche should be continued, and after its use a few drops of an astringent preparation of two grains of sulphate of zinc, two grains of morphia and one ounce of water should be dropped into the ear, or instead of this a solution of fifteen grains of boracic acid and two grains of morphia to one ounce of water may be used. In case there is no pain, the morphia may be omitted, but it does not only seem to relieve the pain, it has also a beneficial effect on the inflammatory process. Inflation of the ear must also be resorted to every day; it should not be used with great force and especially in children it has to be applied very carefully the first time, or the patient may become so frightened that it will be impossible to induce him to submit to its use again. This plan of treatment should be continued until the discharge has disappeared and the perforation of the drum has healed again. Under such circumstances the loss of hearing may be only very slight or be hardly perceptible.

VI. CHRONIC SUPPURATION OF THE MIDDLE EAR, OTORRHŒA.

This disease of the middle ear is one of the most disagreeable and tedious aural affections; not only does it cause great impairment of hearing, but the discharge may become so copious and offensive, that such patients cannot remain in a room for any length of time without infecting it with the foul odor of the dis-be benefited. The patients say that they feel better if the ear is discharging and have unpleasant symptoms and hear much worse whenever the discharge ceases. The cessation of the discharge may be due to the closure of the perforation, and this may in many cases lead to an accumulation of the pus in the tympanic cavity and cause the same unpleasant symptoms that we have spoken of in the preceding lines; upon opening the old one or making a new perforation, the symptoms are at once relieved and the patient attributes it naturally to the reappearance of the discharge.

There is a perforation of the drumhead in nearly all cases of otorrhœa, except in those rare cases where a disease of the mastoid cells or an abscess of the parotid gland resulted in a perforation of the external auditory canal, or in a few cases of diseases of the external auditory canal; in the latter case the discharge is not as purulent as in the former; it is more of a thin serous nature. We can therefore with great probability assume that any purulent discharge from the meatus of the ear is due to a disease of the middle ear.

Symptoms.—1. The most characteristic symptom of this affection is the purulent discharge, which may vary considerably in quantity and quality. In many cases there is only a slight amount of it hardly requiring the daily use of the syringe; in other cases it may be so abundant that the ear has to be cleaned many times a day, and sometimes a change of cotton once a day will be sufficient to absorb the entire discharge secreted during this time. The discharge may be at times very thin, almost serous, but generally it is of a thick, creamy condition; at other times the odor of the secretion may be hardly perceptible, while in other cases it may be very offensive. The abundance of the discharge is often due to the presence of polypi in the ear, and the fetid odor is often caused by an extension of the process to the bone.

2. The appearance of the external auditory canal is greatly changed; the presence of the discharge, keeping the integument of the meatus in a constant moist and irritated state, leads to great swelling and thickening of this part; the canal looks red and exfoliation of its lining membrane is often seen.

3. The auricle is more or less irritated and painful, and may be covered with excoriations and eczematous patches, which are also due to the overflow of the acrid discharge.

4. If the discharge is very insignificant, perhaps not noticed at all by the patient, the canal is more or less congested and especi-

ally the ceruminous glands are greatly irritated, which leads to an increase and to an altered condition of the cerumen; this is generally much harder and of a dark-brown color, and will often be seen in the milder forms of the disease. There is, as a rule, in these cases more or less purulent discharge present, which may be seen after the removal of the hardened wax; however, this must not be taken as a sure sign of disease of the middle ear, because it might come from slight ulcerations of the canal.

5. Changes of the membrana tympani are very marked. There is generally one or a number of perforations of the membrane to be seen (Figs. xliii. and xliv.), which may vary considerably in size as well as in location. The rest of the membrane looks, as a rule, very red and swollen, and it may be entirely covered by thick velvety granulations. The light spot and the manubrium cannot be seen. In many cases we may have very large perforations in the membrane, and sometimes the membrane may have been entirely destroyed or only a slight rim remains of it (Fig. xxxvi.). In such cases the cavity of the middle ear is seen as a red, velvety surface, and the bones may be distinctly seen on top of this red background, or these also may have been discharged.

6. From the edge of the perforation or from the cavity of the tympanum we see frequently large red masses of granulations protruding; some of these are quite large and have a small pedicle; these are called polypi.

7. The bones of the external auditory canal may suffer in rare instances, and necrosis of part of the meatus is apt to become one of the graver complications of a purulent otitis.

8. The disease may affect also the bony canal of the facial nerve, the aqæductus Fallopii, and the nerve is apt to be compressed or destroyed in the course of such an accident, which will result in facial hemiplegia.

9. The result of the suppurative action is of course always great impairment of hearing, especially if both ears are affected, but this may be all out of proportion to the extent of the symptoms. A person may have only a very slight discharge from the ear, or perhaps only one small perforation of the drumhead, and yet be almost deaf; on the other hand the patient may suffer intensely and the drum may be entirely destroyed and yet the hearing may be only slightly affected. This proves that the existence of a perforation or the size of it, and even the absence of the drumhead, has only very little to do with the hearing power. In fact, a person with a perforated drumhead has better chances for hearing than a person with a thick, retracted drumhead.

Treatment.—The main object of the treatment must be directed to the diseased condition of the lining membrane of the middle ear. If this mucous membrane is not cleansed thoroughly from mucus and pus, it must remain in an irritable state, and cleanliness is the first requisite. (Roosa).

The first step in the treatment of the disease should therefore be a thorough removal of the secretion, not only from the external auditory canal, but also from the internal ear. The latter is comparatively easy if we have a large perforation of the drumhead, or if the membrana tympani is entirely absent, and in some cases water may be forced through the tympanic cavity into the throat by means of the ear syringe; but if the perforation is small, the middle ear cannot be cleaned by the use of the syringe and warm water alone. In order to accomplish this it is necessary that the water should be thrown into the ear with some force, which is, as a rule, tolerated by the patient, especially if there is a very large perforation; but in cases where the use of the syringe is painful, the ear-douche should be used instead of it; however we shall hardly be able to force the water through the Eustachian tube into the throat in this case. The cavity of the tympanum can be cleaned very thoroughly in most cases by the use of Politzer's method, which will force all pus and mucus out of the tympanic cavity, if the perforation of the drumhead is not too small. Any remaining particles of dried matter or wax have to be removed with a cotton-holder, if necessary. The parts, being now thoroughly exposed, can be carefully examined. If the perforation is associated with only slight changes of the drumhead, a few drops of a warm astringent and antiseptic preparation, such as a solution of boracic acid 10 grs. to 1 oz. of water, or one of 5 grs. of sulphate of zinc and 5 grs. of alum to 1 oz. of water, may now be dropped into the ear. In case the patient cannot syringe the ear at home, he may use these drops morning and evening by adding five drops of them to half a teaspoonful of warm water, and have this poured into the ear and kept there for about ten minutes. If there is much granulation tissue covering the drumhead, a solution of nitrate of silver may be used; a few drops of a strong solution of it, say from 30 to 60 grs. to 1 oz. of water, may be applied to these granulations by means of a small piece of cotton attached to a probe; or these granulations must be touched with a concentrated solution of chromic acid, applied in the same way as the nitrate of silver. But of far greater value are, in most of these cases, dry applications of either pulverized alum or especially of iodoform, which should be applied very freely, the auditory canal should be nearly filled with it; great care must be taken that the remedy comes in contact with the inflamed membrane and with the granulations; the ear should first be thoroughly cleaned and dried, and then the iodoform is to be pushed down to the bottom of the canal by means of a probe. In order to avoid the unpleasant odor of the iodoform, balsam of Peru in a very small quantity may be added to this disagreeable chemical. Dry preparations have the advantage that they will cause the excoriations of the auditory canal to heal at the same time, and iodoform especially acts not only as an astringent, but also as a disinfectant and anodyne.

In some cases where the drumhead has been destroyed by the ulcerative process, it may be gradually restored again, but if this does not take place, the hearing of the patient may be greatly benefited by a cotton plug, pressed firmly against the middle ear or by an artificial membrana tympani. These latter have sometimes been the means of improving the patient's hearing considerably.

The usual care should be bestowed upon the condition of the throat, because we can hardly expect to cure a disease from above, which is constantly irritated from below. In fact, the rules laid down in the treatment of the acute purulent condition, (page 398), should not be neglected in these cases.

The sequelæ or consequences and complications of chronic purulent inflammation of the middle ear are manifold. 1. In the first place we have large masses of granulations of the drumhead to deal with; some of these, much larger than the rest and distinctly pedicellated, are known as polypi; they project into the auditory canal and may fill it entirely, and in such a case will interfere with the flow of the purulent discharge and also with the hearing of the patient, as the polypi obstruct the passage of the sound-waves. These granulations must be removed (page 384.) or be treated otherwise.

2. Otitis externa or affections of the external auditory canal are caused not only by an extension of the inflammatory process, but principally by the constant contact of the acrid discharge with the lining membrane of the canal. This will be easily exfoliated and may be removed in large pieces by means of the syringe. The excoriations of the meatus heal rapidly if the cause is removed; and the discharge may be easily checked, at least for a time, by the use of dry agents, like iodoform or alum.

3. In long continued affections of this kind, the inflammation will often extend to the periosteum of the bones of the canal and

caries may be the result of this. This may affect a large portion of the meatus, or a small piece of bone only may become diseased. If the disease is recognized in time, the early and frequent use of iodoform might bring about a rapid cure; but even if the dead bone is plainly felt, iodoform should be used. The sequestrum is apt to be disintegrated and discharged, or it becomes loosened, so that it can be easily removed from the canal, sometimes by means of the syringe and sometimes by the use of forceps. Also the bones of the tympanic cavity may undergo great changes; the ossicles may have been lost during the disease and the walls of the tympanum may undergo necrotic changes.

Treatment.—Balsam of Peru, applied to the denuded bone once a day, will be of great service, also the actual cautery has been used. Polypi are apt to develop from this region or they may be caused by the irritation of the rough edges of the sequestrum; they are easily removed, but they are apt to give rise to severe hemorrhages from the ear. Necrosis of the deeper portion of the ear is always full of danger.

4. *Exostoses, or bony growths*, are rarer complications of aural trouble and are in this connection due to an irritation of the periosteum, but they are also met with as a congenital condition (see pag 385.)

5. *Mastoid disease.*—The close relationship of the mastoid cells and the tympanic cavity makes an extension of an inflammatory process from the latter to the first very easy. In fact, it is to be wondered at that in diseases of the middle ear serious disturbances do not arise much oftener from mastoid complication. The mastoid cells are bony cavities communicating with each other and with the middle ear; the mucous membrane is continuous without any interruption from the one into the other. Hence if these cavities take on inflammatory action, the products of the disease can find only one exit and this is into the middle ear. This may help to explain, in some cases, the obstinacy and also the profuseness of an aural discharge. Before a discharge can reach the middle ear, it has to fill those cavities that are on a lower level than the tympanum and remaining here for a long time, the septic material will cause more irritation and may lead to an extension of the disease to the bony structure separating and enclosing the cells. This will of course lead in the beginning to an affection of the periosteum, which becomes congested and inflamed and the integument of the mastoid region will also participate in the process. There is in these cases the most intense pain deep in the ear and also along the whole side

of the head; later a red tense swelling is seen over the mastoid region which may become so tender to the touch, that even the slightest contact of the collar or dress becomes very painful; there is also stiffness of the neck.

At times the tissues in the region of the mastoid process may break down and a deep abscess may be formed before the bone itself becomes seriously affected. The outer plate of bone of the mastoid process, being especially hard and resistant, breaks down only in exceptional cases.

We can therefore divide mastoid affections into those of the periosteum and those of the bone. The first may occur sometimes at an early stage of an acute attack; but it may also develop sometimes after a chronic suppuration had existed for a long time, probably from some retention of the secretion. The symptoms accompanying mastoid disease become very manifest at once; they are tenderness and the most intense pain, but these may sometimes subside without the formation of pus; at other times the process may terminate, as mentioned before, in an abscess of the deeper tissues, and the pus, burrowing its way down through the tissues of the neck, may point a great distance away from its source. The disease may terminate in necrosis of the mastoid bone.

Differential diagnosis.—Disease of the mastoid cells might be mistaken for a swelling due to an inflammation of the surrounding glands, or for a swelling accompanying diseases of the external auditory canal (furuncle), or for a syphilitic enlargement of the troducing a deep-lying seton behind the ear; this may have to remain in place for one or two weeks and should be removed as soon as the swelling subsides. There may be a very copious drain of pus by the seton, but in other cases there is only a very slight serous discharge caused by it. In case it should cause much irritation or if an erysipelatous attack is threatening, it must be removed at once. I have found its use more convenient than that of an incision in some cases, where it would have been necessary to keep the incision open for a long time, but in acute cases the incision should always be resorted to. If there is a superficial or deep abscess of the tissues, it should be opened at its lowest point and should be kept open for some time to admit of thorough drainage of the sac.

6. Caries of the mastoid process is apt to follow periosteal affections in this region. The bone is not sufficiently nourished under such circumstances and is liable to break down or become necrosed. This is more apt to occur where both sides of the bone are affected, or where the bone is less hard or resistent. The septa of the cells are therefore very apt to break down first; next in frequency we have the posterior and upper wall of the external auditory canal which is here surrounded by the mastoid cells. Large portions of the bony part of it may be discharged in the shape of a granular detritus or in larger pieces.

At other times the external layer of bone of the mastoid is resisting and the inflammatory process going on inside in the cells may for many months be the source of the most intense suffering. In these cases the necessity of establishing an opening into the cells and drain them of the purulent discharge becomes evident; if this is neglected the process will in all probability extend farther inwards and result eventually in abscess of the brain. The opening into the bone must be large enough to insure thorough drainage. This end is obtained by trephining through the hard outer plate of the bone until the pus is reached, which is generally in 4 to 7 mm. and until it can be evacuated. The direction of the trephine should be inwards, forwards and upwards. Of course the trephine has to be small, sometimes a gimlet will answer. The periosteum will have to be dissected up before the instrument is used. In infants its use will be seldom called for, the bone being so thin that it is easily perforated. If a fistulous opening has formed spontaneously, this has to be enlarged and kept open, and the cavity must be kept clean by syringing it with carbolized water; this part of the treatment is also necessary after trephining.

The indications for an operative interference in diseases of the mastoid cells are therefore as follows:

A deep incision extending through all the overlying tissues and through the periosteum of the mastoid process in an almost vertical direction should be made in all cases where there is intense pain of the ear and of the surrounding parts that cannot be relieved by the usual treatment, even if the mastoid region is not especially tender. It should principally be made when, after a long-continued purulent disease of the middle ear, the pain and tenderness of the mastoid region becomes very manifest. It becomes also necessary in case of an abscess pointing in this region, and in children it may take the place of trephining, if caries of the mastoid process is suspected.

Perforation of the mastoid bone or trephining is called for in very severe and obstinate attacks of pain in the mastoid region, and especially when necrosis of the septa or of the mastoid process is suspected, and even after the formation of a spontaneous fistulous opening, the use of the trephine may be necessary if the continuance of the pain seems to indicate disease of deeper lying cells, which probably contain pus that cannot be discharged through the already existing opening.

Paralysis of the facial nerve as a result of necrosis has been mentioned before, likewise the occurrence of pyæmia or metastatic abscesses; these may be caused by the entrance of pus into the lateral sinus or by its absorption through the mastoid veins.

Cerebral abscess.—The extension of an inflammation, but especially that of a suppurative process of the middle ear, to the brain is by no means very rare, in fact, disease of the middle ear is the most frequent cause of cerebral abscess. In order to involve the brain the disease must, as a rule, destroy the bony septum of the roof of the tympanum, but it has extended at times through the foramina of the vessels in this location, and purulent meningitis has been observed without extensive lesions of the bone. An extension of the disease to the brain is greatly favored by a blocking up of the pus in the middle ear. Perforation of the membrana tympani, either spontaneously or by operation, is therefore of especial value on this account, and the removal of large polypi or granulation masses of the external auditory canal is also made necessary in order to avoid cerebral complications. The progress of the disease toward the brain may be very slow, and there may be hardly any symptoms to warn us of the approaching danger. This accident may, however, often be hastened by severe colds or by injuries to the head, such as severe falls, producing rupture of the already weakened bone, which may be followed by an acute inflammation of the meninges. At times an abscess may be formed in the brain substance without co-existing meningitis. Vomiting or vertigo, or chills and slight convulsive attacks may be the first signs of the disease; in other cases the attacks are very sudden, without any premonitory symptoms, except that there is perhaps increased pain; there may be the occurrence of paralysis or of coma in the course of the disease, and even sudden deaths may take place without any warning or previous symptoms of a cerebral affection. An occurrence of this kind may in a great many cases be prevented by great cleanliness and by seeing that there is a ready exit for the inflammatory products from the cavity of the tympanum, or from the mastoid cells, in all purulent affections of the middle ear.

CHAPTER XX.

THE INTERNAL EAR.

THE internal ear has been named the labyrinth on account of its complex structure. It is composed of bony cavities formed by the petrous bone; these cavities contain inside another membranous portion, which is separated from the bony part by a clear fluid. It is in this membranous portion that the ultimate nerve fibres are distributed. The bony portion consists of a central irregular cavity, the vestibule, which has at the outer side the fenestra ovalis and the cavity of the tympanum, and internally the meatus auditorius internus with the auditory nerve; anterior to this cavity is another portion of the bony ear, the cochlea, and posterior to it are the semicircular canals.

The vestibule is an irregular cavity and is undoubtedly the most important portion of the ear; it is about 5 mm. wide and high and a little smaller from without inwards. In its inner wall is a small round depression, which is partly perforated by fine holes (*macula cribrosa*) for the passage of the filaments of the auditory nerve. Here is also the opening of the aquæductus vestibuli, which goes through the bone and extends to the posterior surface of the petrous portion of the temporal bone. On the roof are two small depressions, and posteriorly we have the five openings of the semicircular canals. Anteriorly the cochlea opens into the vestibule by a large oval opening.

The semicircular canals are three in number, which start from the vestibule to return to it again, thus forming a semicircle. These canals are of unequal size, but they are all compressed from side to side and have a diameter of about 1.5 mm. The two vertical canals open into the vestibule by one common opening. One of the canals has a horizontal direction, the other two run vertically, at right angles to each other. The direction of the canals is therefore the one vertical, direction from before backwards, the other horizontal, direction from before backward, the last vertical, direction from one side to the other. Some of the openings of these canals are distended (*ampulla*), the rest are less so. The length of the canals is from 15 to 22 mm.

The bony cochlea is a bony canal turning spirally around a central pillar, the modiolus; it forms two turns and a half, each being a little shorter than the first one, which gives it a peculiar snail shell-like appearance; hence the name cochlea. The canal starts at the outer and lower corner of the anterior wall of the vestibule. Its first turn forms the promontory of the middle ear, its last the cupola of the cochlea; the canal is about 28 to 30 mm. long, and the height of the cochlea is about 4 or 5 mm. The canal has at its beginnings three openings, the fenestra rotunda, closed by a membrane, leading to the middle ear, the oval opening into the vestibule, and the aquæductus cochlea for the passage of a small vein. The interior of the canal is divided into two passages or scalæ by a thin bony septum, the lamina spiralis; on this portion the cochlear nerves are distributed. The one passage, the scala tympani, ends in the fenestra ovalis; the other, the scala vestibuli, opens into the vestibule; at the apex the two form one canal by the want of the spiral lamina. The base of the cochlea rests upon the bottom of the internal auditory canal.

The lining membrane of the bony structure of the internal ear is a very thin fibro-serous membrane, partly acting as periosteum, partly as serous membrane. It lines the vestibule and extends posteriorly through the semicircular canals, and anteriorly it is continued into the scalæ of the cochlea. Two delicate tubular processes are prolonged to the inner surface of the dura mater. The lining membrane is also continued over the two fenestræ leading to the middle ear. The inner surface of the periosteum is smooth and is covered with a layer of epithelial cells, which secrete a clear fluid, the *perilymph* or *aqua labyrinthi*. The membrane is abundantly supplied by vessels and from it many fibres and blood-vessels run to the corresponding parts of the labyrinth.

The membranous labyrinth is a closed sac which contains a fluid and crystals; it is of similar shape as the bony vestibule and the semicircular canals, but it is much smaller and is separated from the bone by the perilymph. The fluid inclosed in the interior of it, is called the *endolymph*. The membranous labyrinth is the seat of the terminal fibres of the auditory nerve, which are found here in large numbers. The connection between the two portions the bony and the membranous labyrinth is, however, a very intimate one, and is formed by means of nerve-fibres, blood-vessels and numerous other fibres. The vestibular portion of the membranous ear is divided into two sacs, the *utricle* and the *saccule*. 1. The utricle, the larger of the two, is a flat, somewhat elliptical sac at the upper part of the inner wall of the vestibule; its outer wall is free, and its cavity communicates behind with the five openings of the membranous semicircular canals. It has many filaments of the auditory nerve distributed on its inner surface, and contains an accumulation of fine crystals, *the otoliths*, which are collected as a mass of white powder, held together by a delicate fibrous substance; it is placed opposite the distribution of the nerves. Another similar mass of crystals is found in the other portion of the membranous labyrinth, in the saccule, which is smaller than the utricle, round in shape and placed near the opening into the cochlea; it rests in the fovea hemispherica and receives from here many fibres of the auditory nerve. The walls of the two sacs are united at a single point. The membranous semi-circular canals are much smaller than the bony canals, but their ampulla are comparatively larger and open into the utricle.

The *ductus cochlearis* begins here in the saccule, with which it is joined at nearly right angles, and ends at the apex of the cochlea in another blind sac. The ductus is triangular in shape; its apex is attached to the lamina spiralis, the base to the bony wall of the cochlea; the lower wall is turned towards the scala tympani, and is called the tympanic *wall* or *membrana basilaris;* the upper one turns towards the scala vestibuli; this is the vestibular wall or the *membrana vestibularis;* to the bony lamina spiralis it is attached by means of the limbus of the lamina, which has two lips; between these is a furrow, called the *sulcus spiralis internus.* The cavity of the ductus is divided into two portions by the delicate but firm *membrana corti* or *membrana tectoria;* the upper portion of this is filled with endolymph, the lower one contains the terminal auditory nerve-fibres.

The inner portion of this membrane is structureless and is pierced by numerous foramina, the middle part of it is very dense, and its external surface is made up of a very fine network of fibres and rests directly on the organ of Corti.

The terminal auditory apparatus is composed of the auditory rods or teeth, which are in the lower chamber of the ductus cochlearis; they are arranged like the keys of a piano, having the shape of a Roman S with a broad base; they form two rows which are joined at the apex or head by head-plates. The outer row of these processes or rods is less dense than the inner one, which contains a much larger number of them; there are about six thousand in the inner and four thousand five hundred in the outer row. The inner row is just outside of the perforations in the basilar membrane and the terminal nerve-bundles. From the articulations of the rods a perforated membrane, the *lamina* *reticularis*, arises and runs parallel with the basilar membrane to the outer wall of the cochlea.

The ductus cochlearis contains a number of large cells, *auditory cells*, many of which lie upon the inner pillars, and send processes into the granular layer, which is composed of a row of small cells. The ends of the large cells are turned toward the heads of the rods and have stiff, immovable ciliæ; these are called the *inner hair cells*, of which there are about three thousand three hundred. On the outer rods we have a layer of double nucleated cells, which are connected by slender processes to the basilar and reticular membrane; these have likewise stiff ciliæ and are called the *outer hair cells*, there are about one thousand eight hundred of these cells. This constitutes the organ of Corti, which is located in the ductus cochlearis. Some portions of it are quite peculiar to man and other mammals.

The auditory nerve (*nervus acusticus* or *portio mollis* of the seventh pair) is the special nerve of the sense of hearing. It is very soft in texture, has a very thin neurilemma and takes its origin from the gray matter of the medulla oblongata by two roots. The smaller one of these arises by white striæ from a ganglionic nucleus on the floor of the fourth ventricle; the second or large root originates in a nucleus in the crus cerebelli and has a small ganglion connected with it soon after leaving the medulla.

The two roots unite and form the auditory nerve, which enters the meatus auditorius internus. The auditory nerve is also connected with the gray substance of the cerebellum, the flocculus and the calamus scriptorius. As the nerve winds around the restiform body, from which it receives also some fibres, it is joined by the facial nerve (*portio dura* of the seventh pair), and these two nerves run together to the bottom of the internal auditory canal, which is about 8 mm. long and runs directly outwards.

At this point the facial nerve enters the Fallopian canal and the auditory nerve divides into two branches at the porus acusticus. One of these, the cochlear branch, much larger than the other, the vestibular branch, passes to the modeolus of the cochlea and, after giving off some smaller branches to the lower portion of the lamina spiralis, passes up through all the windings of the cochlea and is ultimately distributed to the inner and outer hair cells of the organ of Corti, the terminal fibres passing through the fine perforations in the labium tympanicum and membrana vestibularis.

The vestibular branch of the auditory nerve, after passing through a small ganglion, divides into three portions. These branches are the ampullar, going to the ampulla of the inferior, vertical semi-circular canal, the middle branch for the saccule and the superior one, which terminates in the utricle and the ampullæ of the semicircular canals.

The internal ear receives its blood supply from the cerebral as well as from peripheral arteries, the principal one being the internal auditory, which takes its origin from the basilar artery; it divides at the bottom of the internal meatus into the cochlear and the vestibular artery. The veins of the vestibule and the canals accompany the arteries; these veins as well as those of the cochlea terminate in the superior petrosal sinus. The vessels of the internal ear do not anastomose to any extent with those of the tympanum, and this may explain why the diseases of the latter do not, as a rule, extend to the internal ear.

DISEASES OF THE INTERNAL EAR.

Affections of the internal ear are generally spoken of as nervous deafness; they are fortunately quite rare, which is probably due to the isolated and protected position of this portion of the auditory apparatus, and also injuries of it are not often met with on this account.

The recognition of diseases of this part of the ear has to be based especially upon the loss or great impairment of hearing, there being no external or visible changes of the ear to help us in our diagnosis, they being similar to some affections of the eye, amblyopia for instance, in which impairment of vision is the only symptom of the disease.

The seat of a lesion of the auditory nerve may be central, located in the brain or in the medulla, or peripheral, when the bony or membranous labyrinth is diseased. In the former impairment or entire loss of hearing alone may be present; in affections of the labyrinth the diminution of hearing is accompanied by vertigo and tinnitus aurium and sometimes even by nausea and vomiting. A central lesion may implicate the auditory nerve by affecting the origin of it or by compressing it on its way to the labyrinth, and of these causes specific disease (gummata), cerebral tumors or a basilar meningitis are of most frequent occurrence. Cerebral hemorrhages may also give rise to deafness, but under these circumstances the general condition of the patient is such a serious one, that the loss of hearing, especially of one side only, is easily overlooked.

Nervous deafness may also be caused by large doses of quinine; these produce congestion of the nerve, principally of the terminal fibres in the cochlea, and this is sometimes followed by complete deafness, which, however, is not always permanent. Meningitis, and especially cerebro-spinal meningitis, are sometimes followed by deafness, and in many cases the cause of this is an implication of the fourth ventricle or an extension of the purulent infiltration of the arachnoid to the internal ear by means of the auditory nerve itself; there is often a staggering gait in these cases. Deafness may also be due to the rare occurrence of an aneurism of the basilar artery, or to anæmia of the nerve, as we see it in severe debilitating constitutional diseases.

The peripheral causes are manifold; they may be injuries, such for instance as fractures of the petrous portion of the temporal bone leading to an inflammation of the membranous ear or causing injury to the nerve itself, or the deafness may be due to syphilitic periostitis of the bony ear, to a general diffuse inflamation of the temporal bone or to concussions of the nerve; either from falls, from cannonading, or from working in a boiler-shop. Hemorrhages and serous effusions into the labyrinth may lead more or less directly to lesions of the acoustic nerve; they cause sudden deafness and vertigo and are known as Ménière's disease, if affecting the semicircular canals. Affections due to peripheral causes, if these do not remain at work long enough to result in destruction of the nerve-fibres, may be followed by improvement of hearing and even by complete recovery. In many cases affections of the internal ear may be secondary to inflammatory processes of the middle ear. Nature has, however, protected the internal ear carefully and the membranous labyrinth does not come in contact with the wall separating it from the middle ear, nor is its vascular system connected with that of the middle ear.

Symptoms.—The most important and we may safely say pathognomonic symptom of lesions of the internal ear is absolute deafness.

A very characteristic sign in some of these cases is a staggering gait or loss of equilibrium. The patient, especially if his eyes are closed, cannot walk straight, he tumbles over, generally to the side of the affected ear. This symptom is supposed to be due to an affection of the semicircular canals and has been called *Ménière's disease*, because Ménière was the first to describe it. This affection makes its appearance suddenly, is accompanied with complete deafness of one side, intense vertigo, marked tinnitus aurium, nausea or vomiting, faintness and uncertainty in walking or standing. As the semicircular canals are the organs of the equilibrium or of the sense of space, the last symptom seems to be of the greatest importance. The absence of paralytic complications speaks in these cases for a peripheral seat of the disease, and a normal appearance of the drum would exclude affections of the middle ear; the Eustachian tubes are also free of any diseased condition in this disease.

Differential diagnosis.—Sudden cessation of hearing is generally due to internal disease, if it is not caused by impacted cerumen, which can be easily excluded by an aural examination, and by the fact that the hearing power is only impaired. In diseases of the middle ear vertigo and sudden and great impairment of hearing must be due to extensive exudation into this cavity and must affect the drumhead to a great extent. Nausea and vomiting are seldom seen in diseases of the middle ear and would point strongly to an affection of the internal ear.

For a differential diagnosis of these two affections the tuning-fork is also of the greatest service; it is not heard at all in diseases of the internal ear, but is heard much better than in the normal ear in affections of the tympanic cavity. The drumhead, which is generally changed in diseases of the middle ear, is as has been said not affected in deeper lesions.

Compression of the acoustic nerve due to an aneurism of the basilar artery is generally accompanied by difficulty in deglutition and the most intense tinnitus aurium. If the disease is due to a cerebro-spinal meningitis the patient complains early about intense tinnitus aurium, aural hallucinations, and sometimes even about pain in the ear; this is soon followed by great deafness. Injuries, especially a severe fall or blow on the head, may result in concussion of the nerve only, but they are generally accompanied by hemorrhages into the ear or by a fracture of the base of the skull. Such an accident may cause a fracture implicating the petrous portion of the temporal bone, or it may result only in a rupture of the drumhead. In the first case a long continued flow of a clear salty liquid, the arachnoid fluid, is present from the ear and frequently also from the nose. Such a fracture takes place as a rule opposite to the side of the injury by contre-coup. Rupture of the membrana tympani alone is sometimes followed by a discharge of little blood, at other times by severe bleeding. The prognosis is of course much more favorable in such a case than in one where the discharge is serous and abundant. Injuries of the middle ear alone after such accidents are diagnosed by means of the tuning fork.

Peculiar anomalies of hearing have been observed in affections of the cochlea; at times certain tones are not heard at all especially very high ones, or certain notes are heard different as if they were of a higher or lower pitch, or there may be double hearing, where every last word heard is heard repeated or echoed. Some of these symptoms are, however, congenital peculiarities; there are, for instance. people that never heard a cricket, which is said to produce the highest tone that is known, but hear perfectly well otherwise. Again some of these symptoms, for instance double hearing, may be observed in diseases of the middle ear and may be due to pressure exerted by inflammatory products on the labyrinth.

The treatment of affections of the internal ear must of course be suited to the original causes of the disease, and unfortunately these are in the majority of cases beyond our control. In specific lesions the prognosis is more favorable and the treatment is soon followed by improvement. As these lesions, which are connected with the ear, are mostly tertiary manifestations, the use of large doses of iodide of potassium or of the iodide of sodium, combined with small doses of mercury, must be resorted to at once. The formula on (page 170), will be found of great service.

Acute inflammatory diseases should be treated antiphlogistically; a large artificial leech or half a dozen of common leeches may be used and cold applications should be made to the head, but the ears should be plugged carefully with cotton, in order to keep the ice-water from running into the ear. In chronic cases counter-irritation, such as a blister behind the ear, strychnia in moderate doses and electricity, especially the galvanic current may be tried.

Otalgia nervosa, or *neuralgia of the ear*, or *nervous ear-ache*.—An ear-ache, if not depending upon inflammatory processes but upon reflex action, is very rare; it may be caused by a decaying tooth, or by an ulcerative process in the larynx, or it may be periodical, due perhaps to malarial influences. In the first cases removal of the cause and in the latter the use of a dose of ten grains of caffein, or in malarial cases the use of Fowler's solution of arsenic in five to ten drop doses, three times a day, will be found of great service.

Morbid growths of the auditory nerve are generally of a sarcomatous or fibrous nature; they are seldom primary affections, the original disease having its seat generally in the temporal bone.

DEAF-MUTEISM.

This may be a congenital or an acquired condition. The former is due to a congenital defect of the auditory apparatus; the child does not learn to speak, and this is sometimes the first sign that there is something wrong in regard to the hearing of the child. The second variety, acquired deaf-muteism, will develop if children become deaf before they were intelligent enough to speak, or where the affection of the ear took place shortly after they learned to speak; but it has happened that children became deaf-mutes after losing their hearing during their seventh or even ninth year; nor does it require absolute deafness in small children, as deaf-muteism may develop itself from none-use of the ear.

Such children offer the best prognosis in regard to treatment; but the danger of poor hearing in young children is very great, and a case of chronic catarrh with impaired hearing, that would only inconvenience an adult, may in a child lead slowly to deaf-muteism. The causes of congenital deafness do not only depend upon absence of the auditory canal; it may be due to a congenital lesion of the nerve itself or especially to lesions of the fourth ventricle.

In regard to the treatment of congenital deafness nothing can be done; in acquired deafness, the greatest care should be used to relieve the aural disease and to educate the child by speaking to it slowly and loud and frequently, showing to it the object spoken of at the time. In many cases an ear-trumpet and perhaps also the audiphone may be employed to great advantage, of course only in those cases due to disease of the middle ear; in lesions of the nerve itself they are quite useless. The child should also be induced to repeat aloud everything that is said.

Of other causes of deaf-muteism cerebro-spinal meningitis plays an important role; or the affection may be inherited, it may run in some families or it may be like retinitis pigmentosa due to blood-relationship of the parents; in fact these two diseases are sometimes seen together. Diphtheria and scarlatina are sometimes followed by deaf-muteism, and the same occurs, perhaps not so often as in the first-named diseases, in typhoid conditions or after meningitis.

As a remedy for acquired deaf-muteism electricity has been used extensively, but seldom with any permanent results. In order to apply electricity to the ear, the external auditory canal should be filled with warm water, a small electrode is likewise introduced into the canal, and the other, the negative pole, may be applied to the back of the neck, or it may be applied in connection with a peculiarly arranged Eustachian catheter to the tube. The galvanic as well as the faradic current have been employed for the ear.

Even in old cases of deaf-mutism, especially of the acquired variety, local treatment of the ear and throat, independent of any hope of restoring the hearing of the patient, should not be neglected.

The cavity of the middle ear is in such patients often the seat of a chronic suppurative inflammation, the products of which will give rise to a disagreeable irritating discharge, and may, if not attended to, lead to excoriations of the external auditory canal and auricle. Sometimes the process may extend to the mastoid cells or lead even to cerebral affections. Cleanliness and the local use of Iodoform should play an important rôle in the treatment of such cases, (see page 413.) Also the throat affections, which are generally of a hypertrophic form and give rise to much local irritation and expectoration, should be carefully attended to.

200 feet or 60m.

O

V = $\frac{20}{200}$ or $\frac{1}{10}$.

100 feet or 30m.

C F

V = $\frac{20}{100}$ or $\frac{1}{5}$.

The numbers above the letters indicate the distance, in feet and metres, at which they are seen under an angle of five minutes; those below each series of letters express the amount of vision which a patient has that can recognize such types only at a distance of twenty feet from the eye.

80 feet or 24m.

L H

V = $\frac{20}{80}$ or $\frac{1}{4}$.
60 feet or 18m.

T R

V = $\frac{20}{60}$ or = $\frac{1}{3}$.
50 feet or 15m.

E U L

V = $\frac{20}{50}$ or $\frac{2}{5}$.
40 feet or 12m.

F D T G

V = $\frac{20}{40}$ or = $\frac{1}{2}$.
30 feet or 9m.

P G D F T

V = $\frac{20}{30}$ or $\frac{1}{3}$.
20 feet or 6m.

U O F L P H E

V = $\frac{20}{20}$ or = 1.

SNELLEN'S TEST-TYPES.

D = 0,5.

T[illegible] tribes fell off, and sued for peace. Even [illegible] became weary of the hopeless contest, [illegible] after much capricious hovering, settled [illegible] the Roman side. Had Civilis been suc[illegible] [illegible] have been deified; but his misfortunes, [illegible] in spite of his heroism. But the Batavian was not a man [illegible] he lived so long in the Roman [illegible] matched in politics by the [illegible] He was not to be sacrificed [illegible] revengeful Rome. Watching from beyond the [illegible] the progress of defection and the decay [illegible]

D = 0,6.

enthusiasm he determined to be beforehand with those who were [illegible] accepted the offer of negotiation from Cerialis. The Roman general was [illegible] [illegible] pardon and to re-enlist so brave a soldier in the service of the em[illegible] agreed upon. The bridge across the Nabalia was broken asunder in the [illegible] and [illegible] met upon the severed sides. The placid stream by which [illegible] connected the waters of the Rhine with the lake of Flevo, howev[illegible]

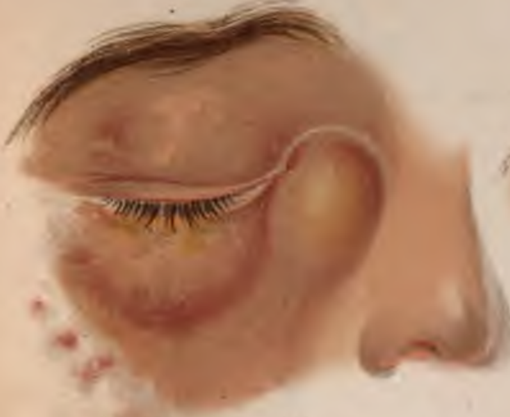
D = 0,8.

commander and the rebel chieftain. — Here the story abruptly termin[illegible] The remainder of the Roman's narrative is lost, and upon that broken [illegible] the form of the Batavian hero disappears for ever. His name fades [illegible] history, not a syllable is known of his subsequent career; everything buried in the profound oblivion which now steals over the scene wh[illegible] was the most imposing actor. The contest of Civilis with Rome contai[illegible]

D = 1.

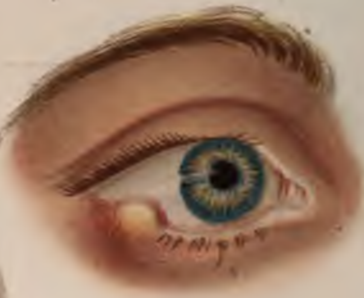
PLATE I.

1



Acute Dacryocystitis

2



Hordeolum

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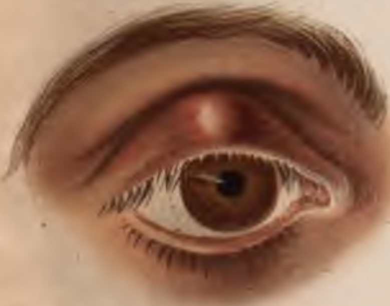
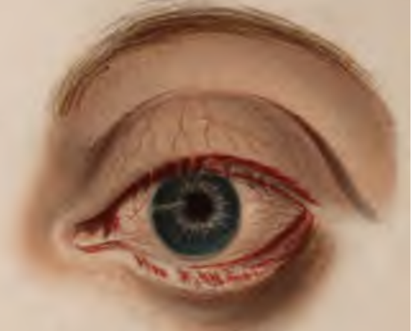


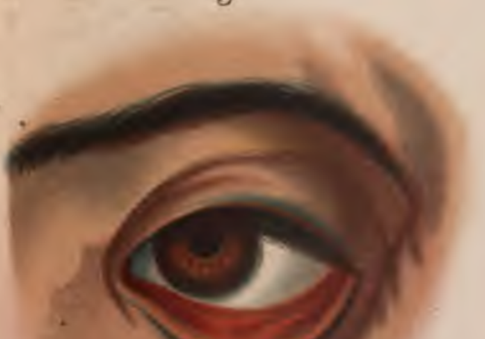
Chalazion

4



Blepharadenitis

5



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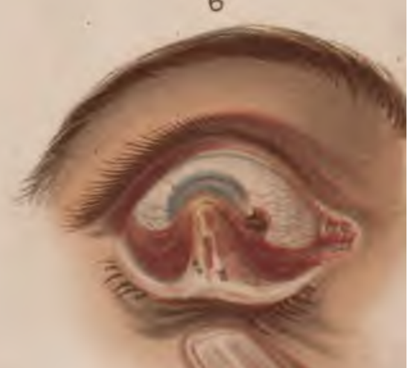
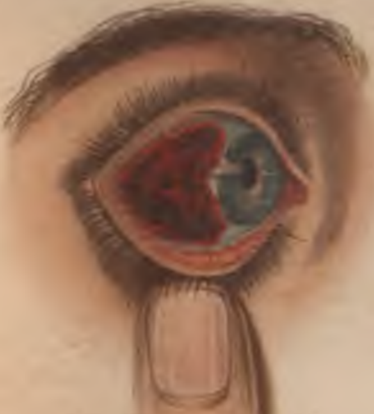


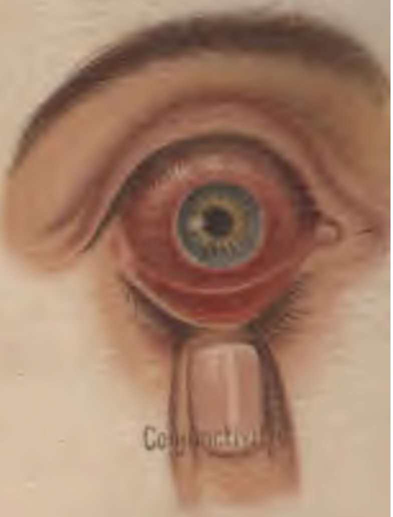
PLATE II.

7



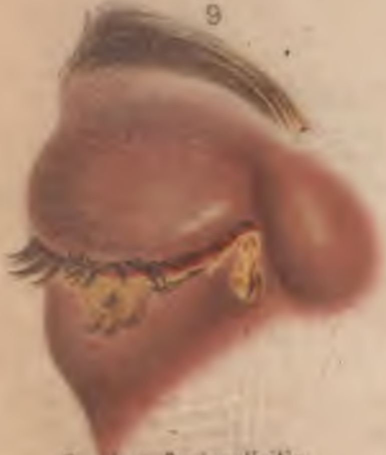
Ecchymoma subconjunct

8



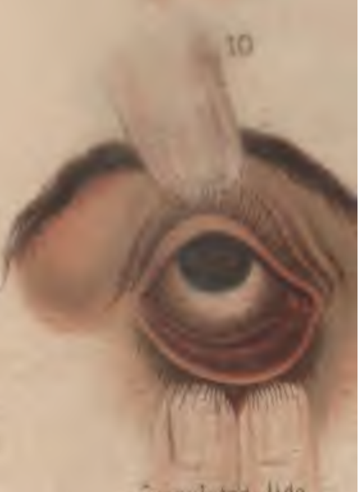
Conjunctivitis

9



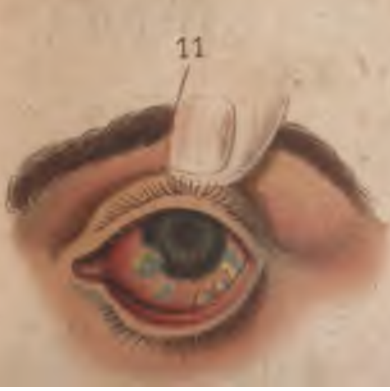
Purulent Conjunctivitis

10



Granulated lids

11



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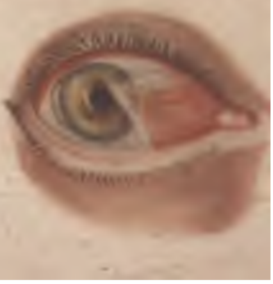

PLATE II.

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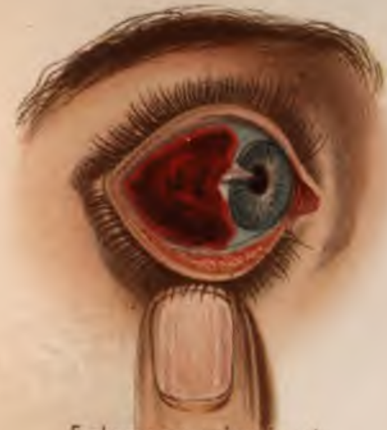

Ecchymoma subconjunct

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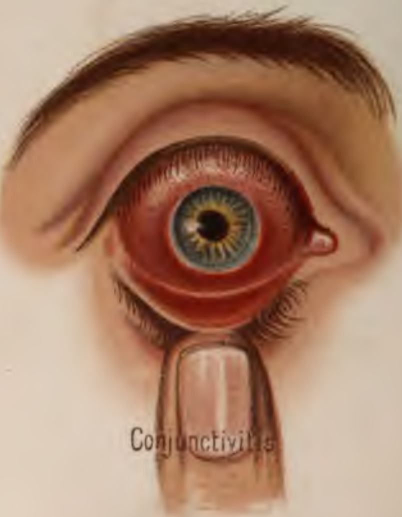

Conjunctivitis

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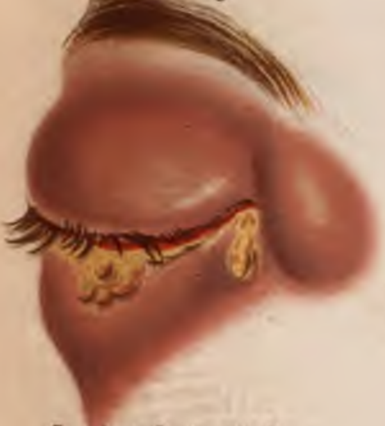
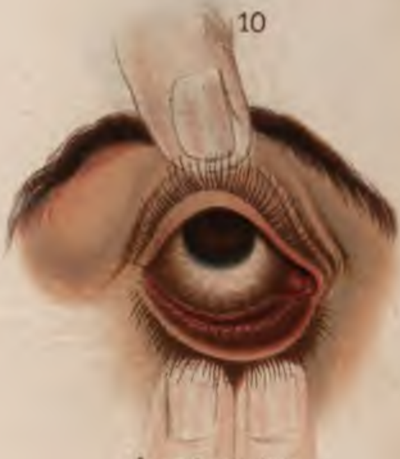


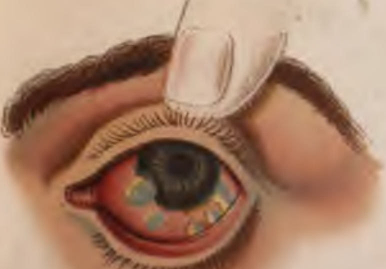
Purulent Conjunctivitis

10



Granulated lids

11



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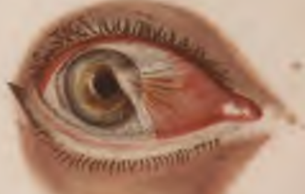
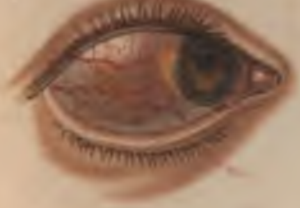


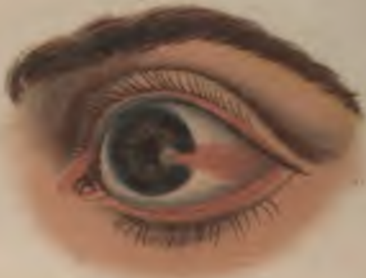
PLATE III.

13



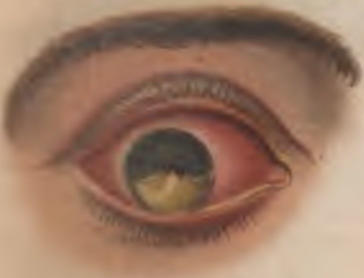
Episcleritis

14



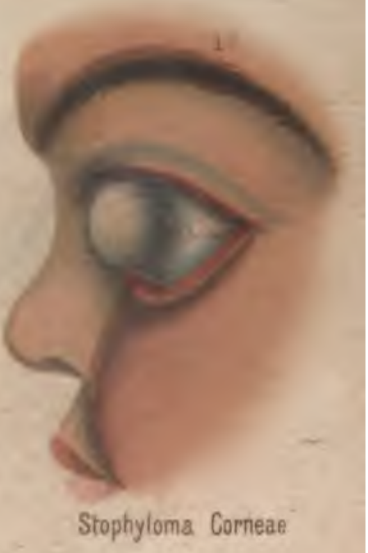
Phlycten Keratitis

15



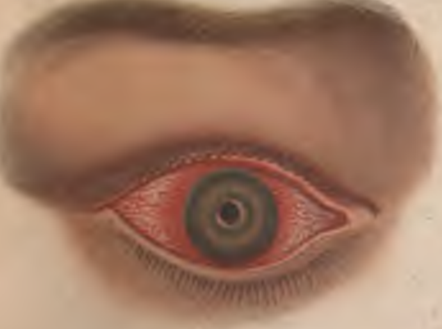
Hypopion Keratitis

1



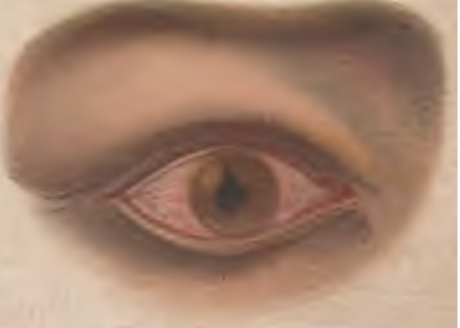
Stophyloma Corneae

17



Iritis

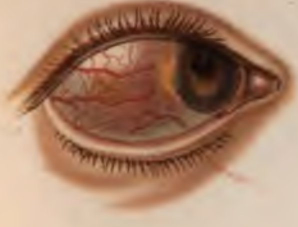
18



Iritis, irregular pupil.

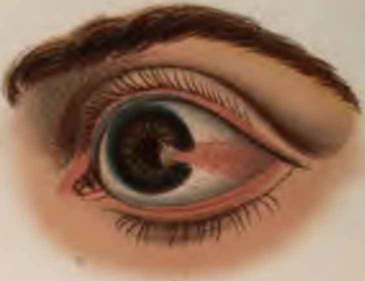
PLATE III.

13



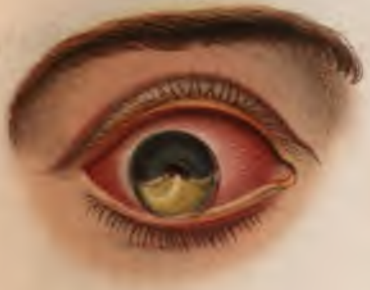
Episcleritis

14



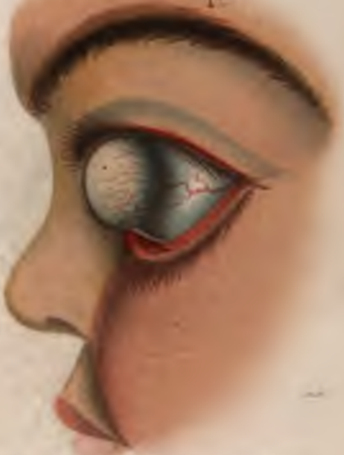
Phlycten Keratitis

15



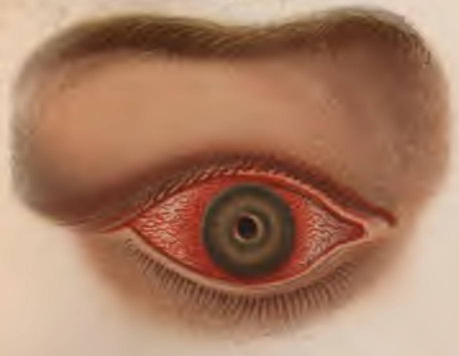
Hypopion Keratitis

16



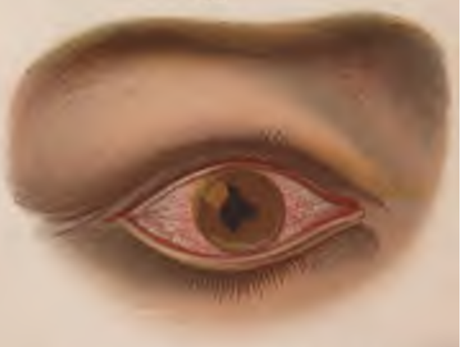
Stophyloma Corneae

17



Iritis

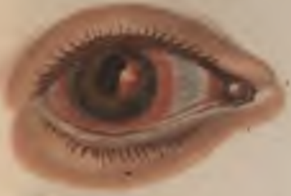
18



Iritis, irregular pupil.

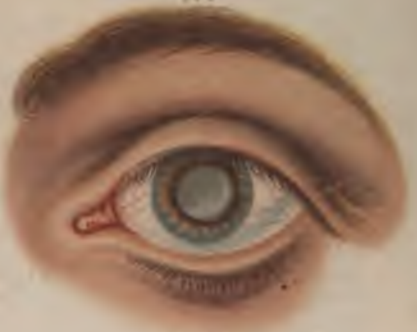
PLATE IV.

19



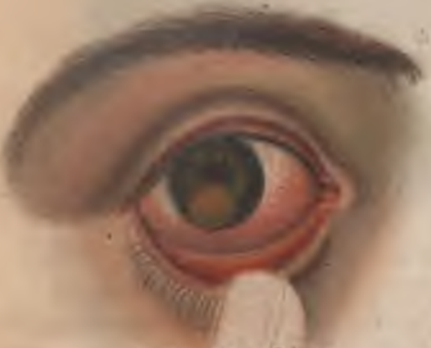
Syphilitic Iritis (Condyloma)

21



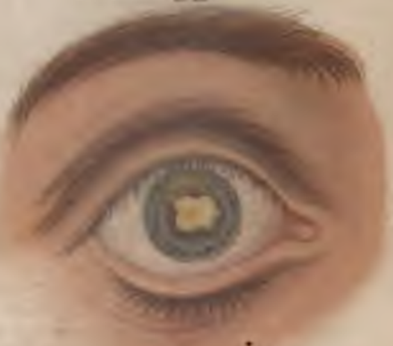
Soft Cataract

20



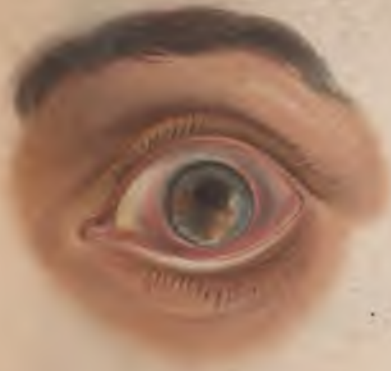
Dislocation of lens

22



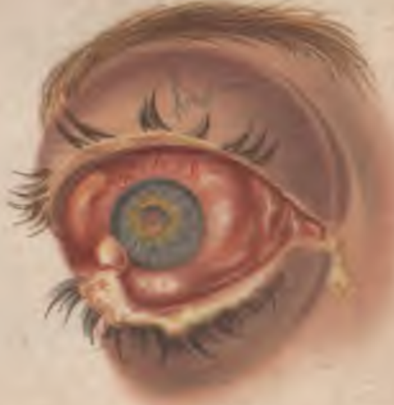
Complicated Cataract

23



Irido-Choroiditis

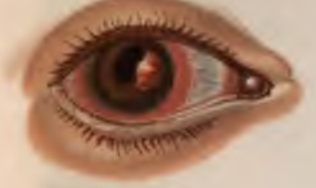
24



Panophthalmitis.

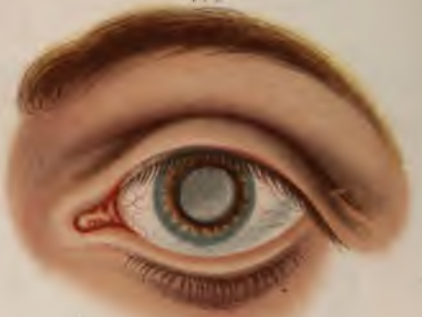
PLATE IV.

19



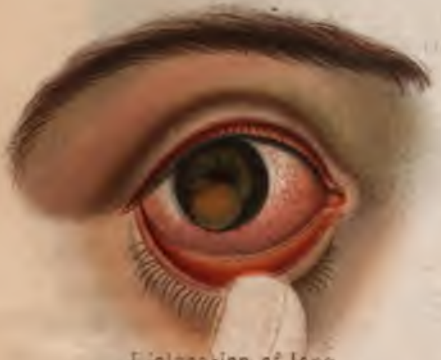
Syphilitic Iritis (Condyloma)

21



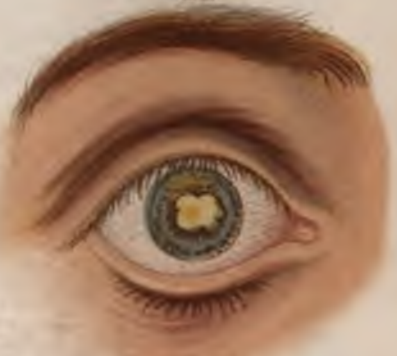
Soft Cataract

20



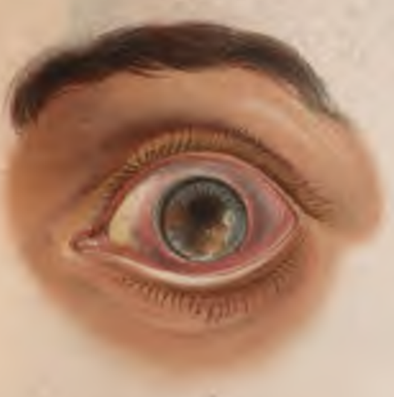
Dislocation of lens

22



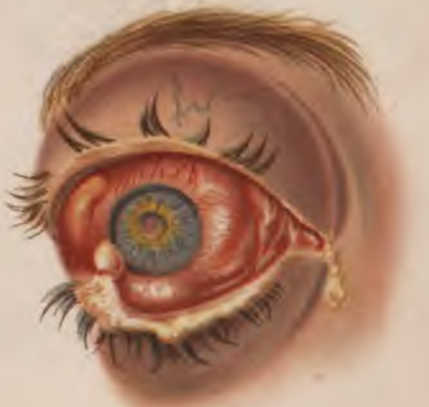
Complicated Cataract

23



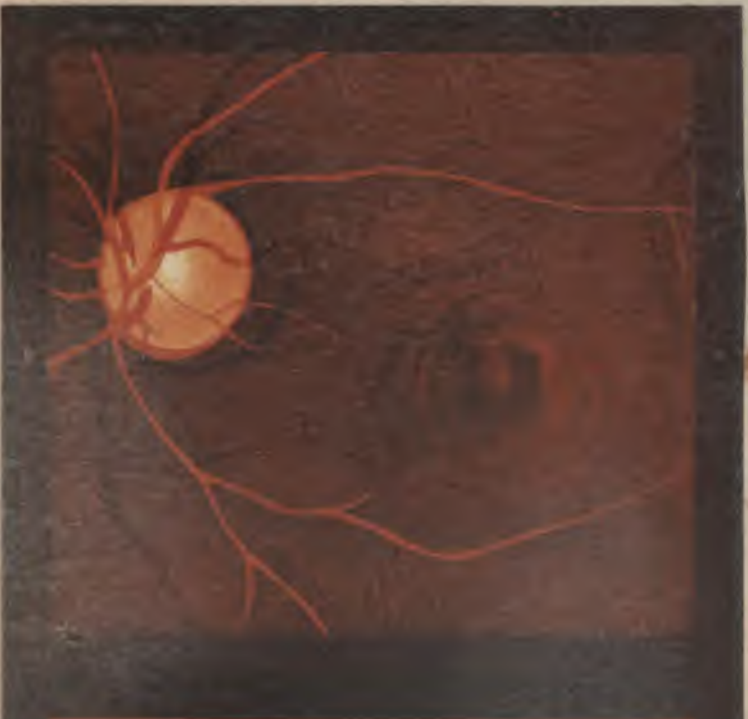
Irido-Choroiditis

24



Panophthalmitis.

PLATE V.



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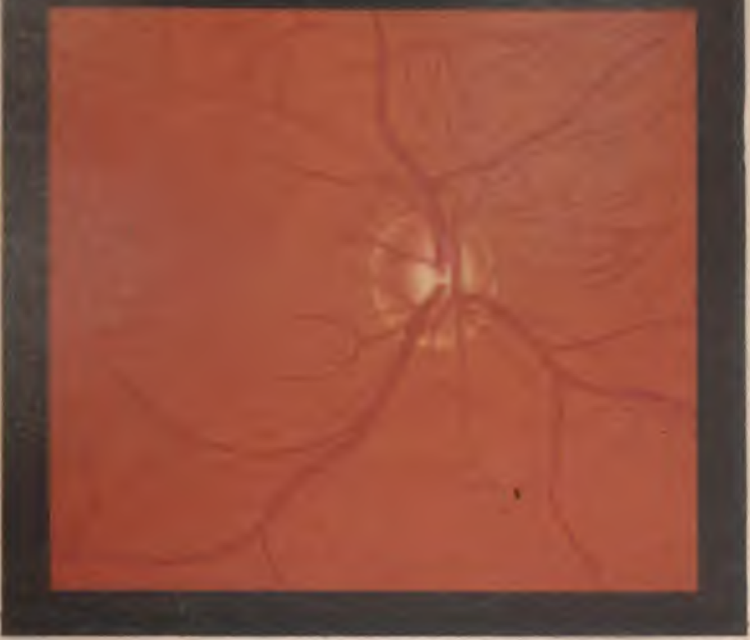


26

200 feet or 60m.

O

$V = \frac{20}{200}$ or $\frac{1}{10}$.

100 feet or 30m.

C F

$V = \frac{20}{100}$ or $\frac{1}{5}$.

The numbers above the letters indicate the distance, in feet and metres, at which they are seen under an angle of five minutes; those below each series of letters express the amount of vision which a patient has that can recognize such types only at a distance of twenty feet from the eye.

80 feet or 24m.

L H

V = $\frac{20}{80}$ or $\frac{1}{4}$.

60 feet or 18m.

T R

V = $\frac{20}{60}$ or = $\frac{1}{3}$.

50 feet or 15m.

E U L

V = $\frac{20}{50}$ or $\frac{2}{5}$.

40 feet or 12m.

F D T G

V = $\frac{20}{40}$ or = $\frac{1}{2}$.

30 feet or 9m.

P G D F T

V = $\frac{20}{30}$ or $\frac{1}{3}$.

20 feet or 6m.

U O F L P H E

V = $\frac{20}{20}$ or = 1.

SNELLEN'S TEST-TYPES.

D = 0,5.

The Gallic tribes fell off, and sued for peace. Even the Batavians became weary of the hopeless contest, while fortune, after much capricious hovering, settled at last upon the Roman side. Had Civilis been successful, he would have been deified; but his misfortunes, at last, made him odious in spite of his heroism. But the Batavian was not a man to be crushed, nor had he lived so long in the Roman service to be outmatched in politics by the barbarous Germans. He was not to be sacrificed as a peace-offering to revengeful Rome. Watching from beyond the Rhine the progress of defection and the decay of national

D = 0,6.

enthusiasm, he determined to be beforehand with those who were now his enemies. He accepted the offer of negotiation from Cerialis. The Roman general was eager to grant a full pardon, and to re-enlist so brave a soldier in the service of the empire. A colloquy was agreed upon. The bridge across the Nabalia was broken asunder in the middle, and Cerialis and Civilis met upon the severed sides. The placid stream by which Roman enterprise had connected the waters of the Rhine with the lake of Flevo, flowed between the imperial

D = 0,8.

commander and the rebel chieftain. — Here the story abruptly terminates. The remainder of the Roman's narrative is lost, and upon that broken bridge the form of the Batavian hero disappears for ever. His name fades from history; not a syllable is known of his subsequent career; everything is buried in the profound oblivion which now steals over the scene where he was the most imposing actor. The contest of Civilis with Rome contains a

D = 1.

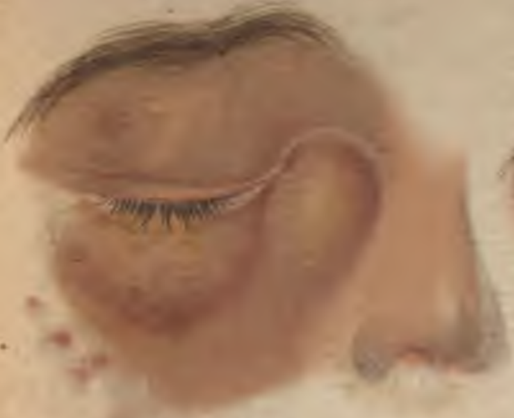
remarkable foreshadowing of the future conflict with Spain, through which the Batavian republic, fifteen centuries later, was to be founded. The characters, the events, the amphibious battles, desperate sieges, slippery alliances, the traits of generosity, audacity, and cruelty, the generous confidence, the broken faith, seem so closely to repeat themselves, that history appears to present the

D = 1,25.

selfsame drama played over and over again, with but a change of actors and of costume. There is more than a fanciful resemblance between Civilis and William the Silent, two heroes of ancient German stock, who had learned the arts of war and peace in the service of a foreign and haughty world-empire. Determination,

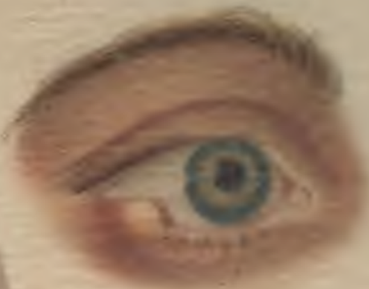
PLATE I.

1



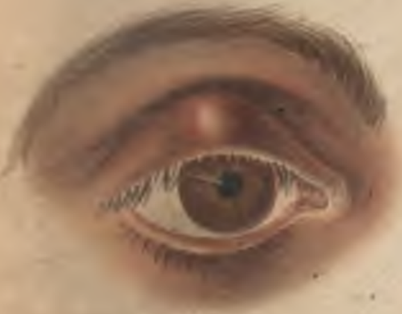
Acute Dacryocystitis

2



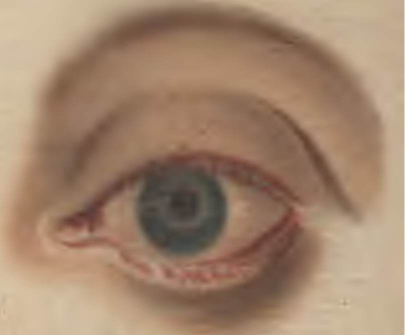
Hordeolum

3



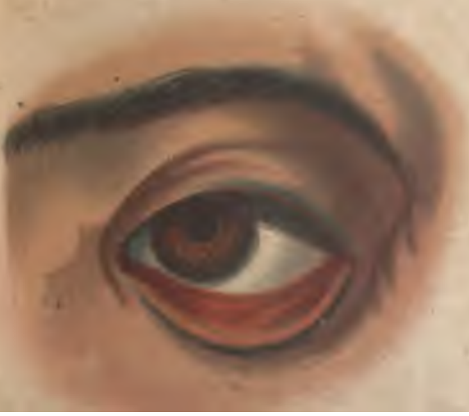
Chalazion

4



Blepharadenitis

5



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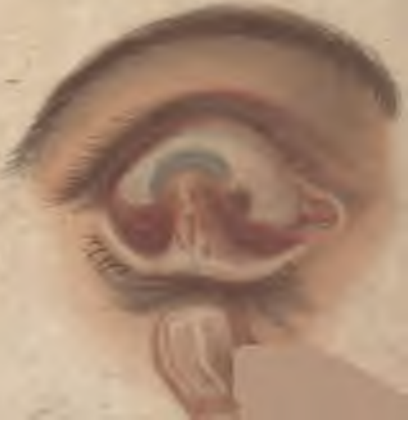


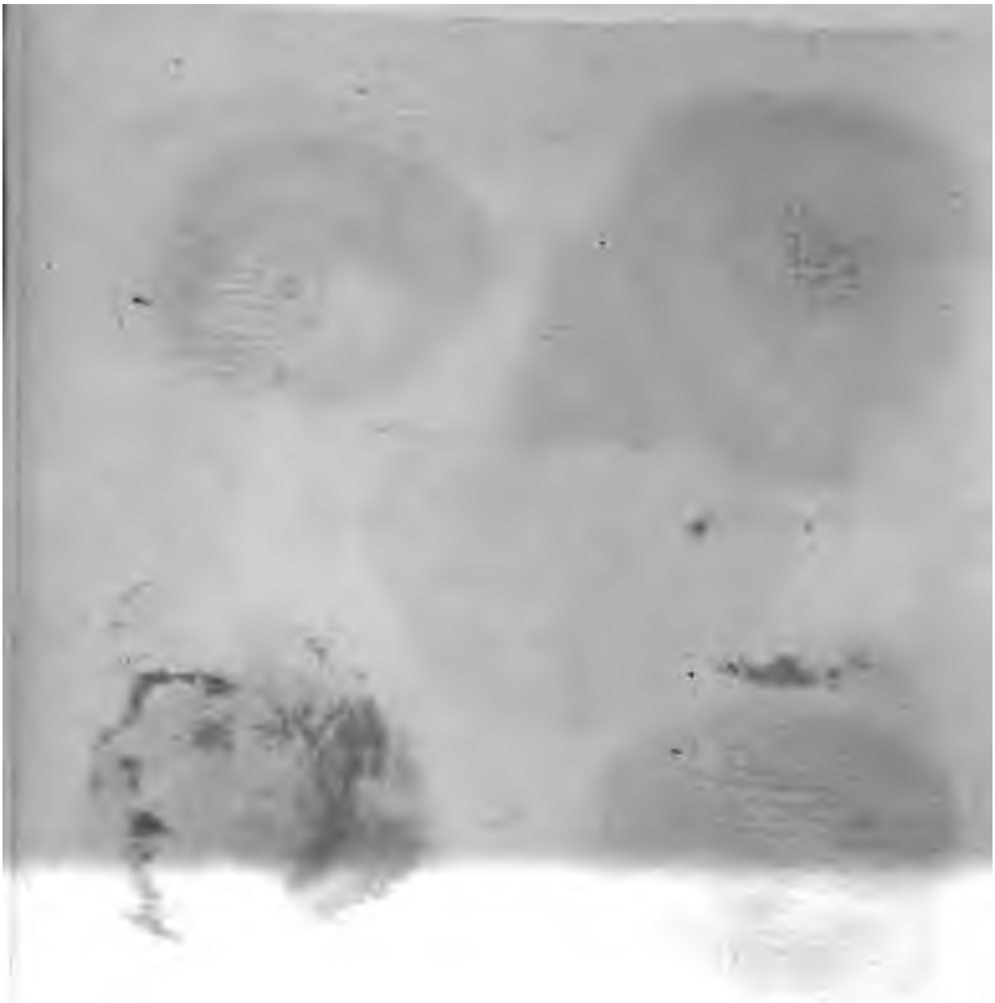
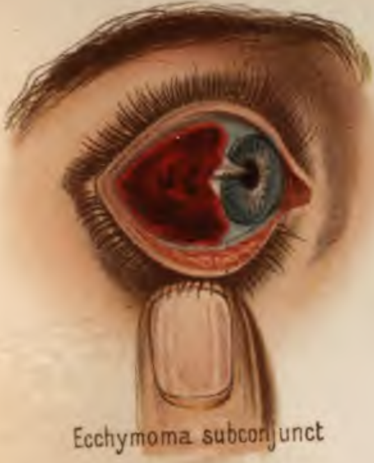


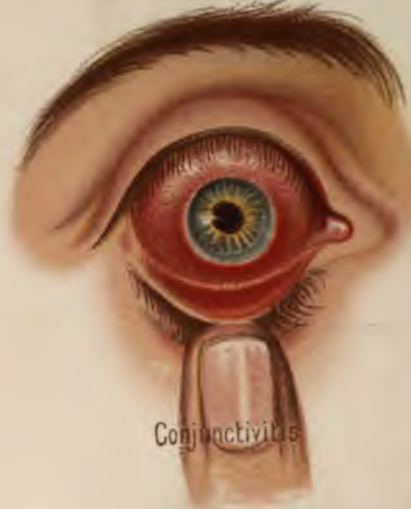
PLATE II.

7



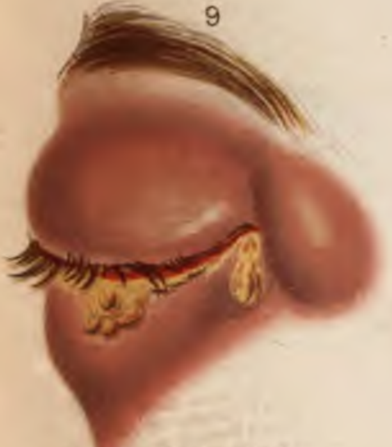
Ecchymoma subconjunct

8



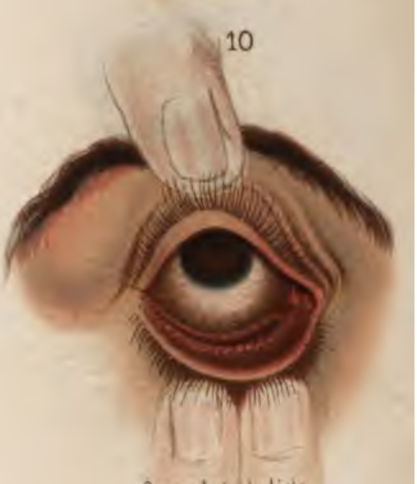
Conjunctivitis

9



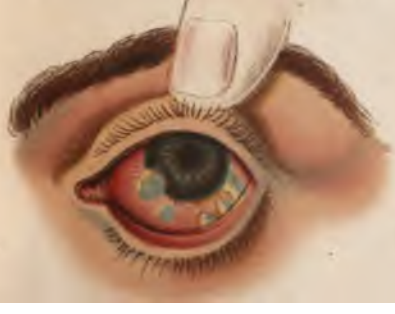
Purulent Conjunctivitis

10



Granulated lids

11



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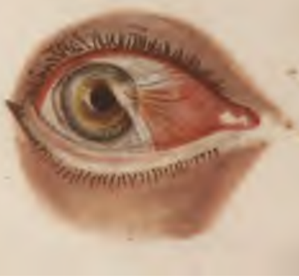
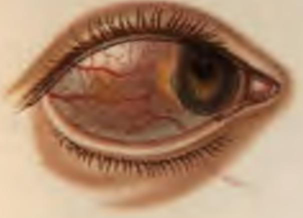


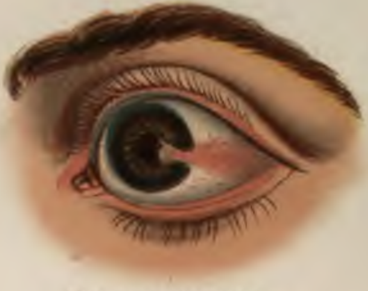
PLATE III.

13



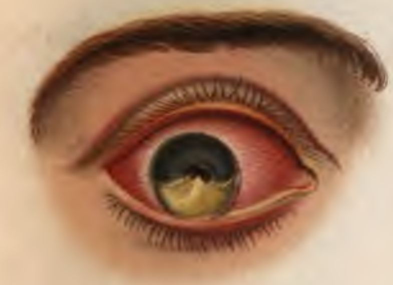
Episcleritis

14



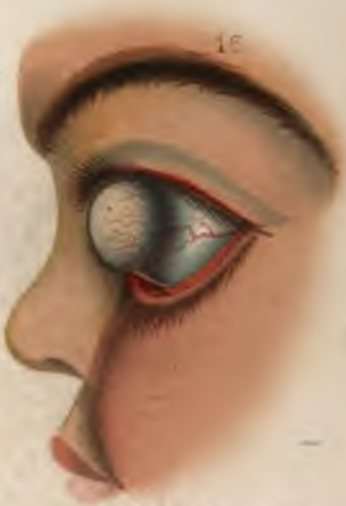
Phlycten Keratitis

15



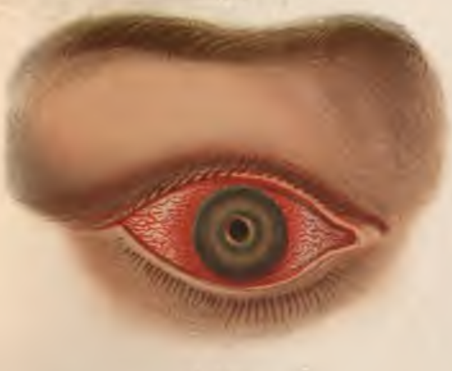
Hypopion Keratitis

16



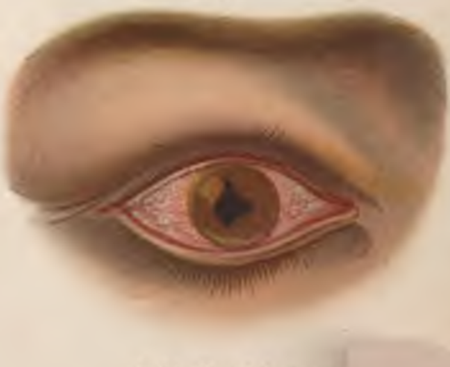
Stophyloma Corneae

17



Iritis

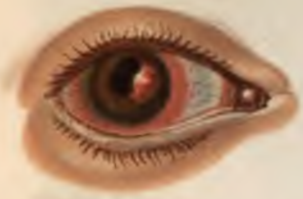
18



Iritis, irregular pup

PLATE IV.

19



Syphilitic Iritis (Condyloma)

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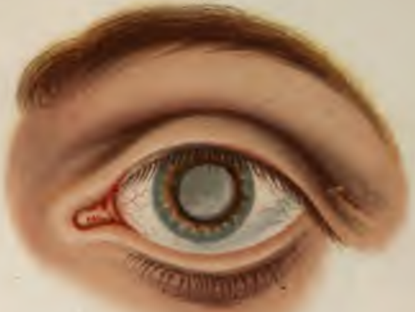

Soft Cataract

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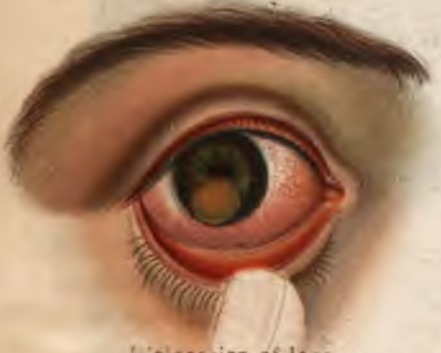

Dislocation of lens

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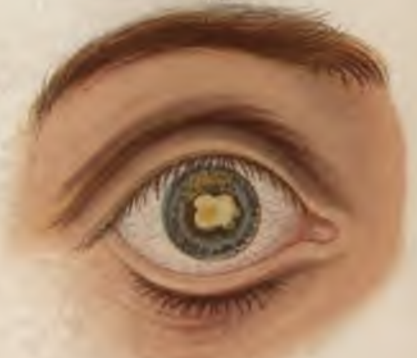

Complicated Cataract

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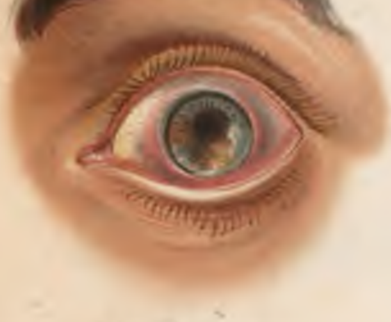

Irido-Choroiditis

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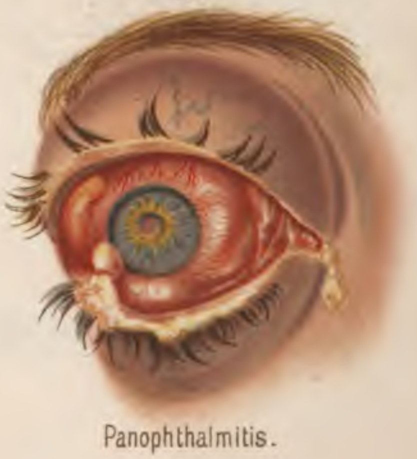

Panophthalmitis.

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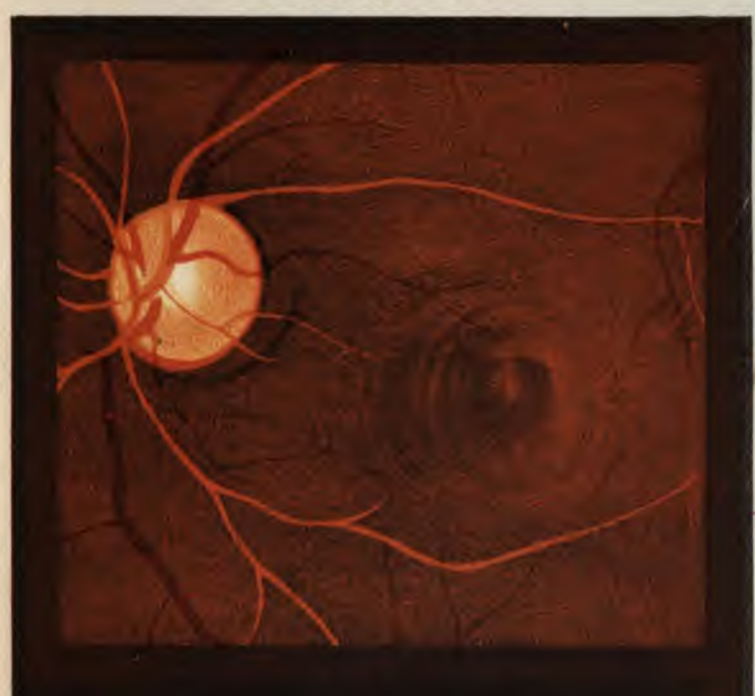

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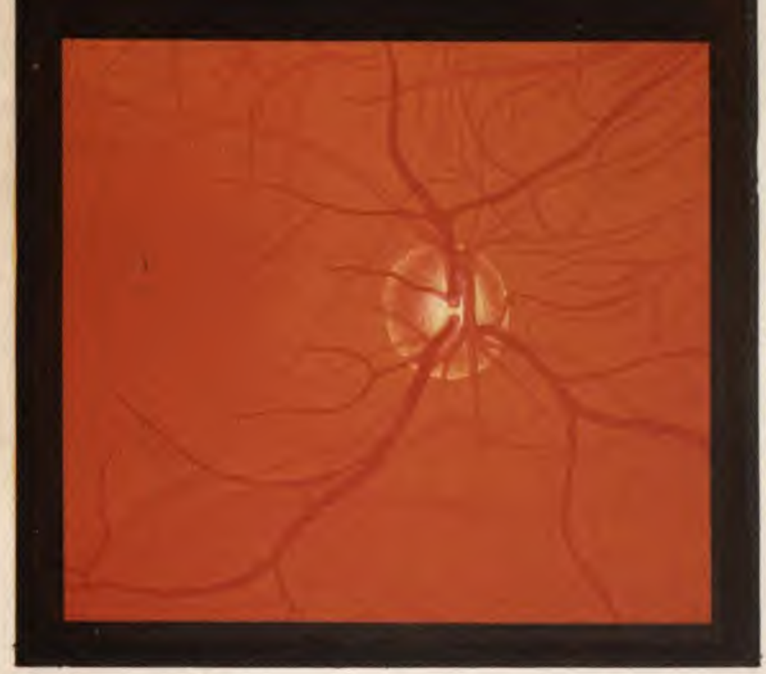

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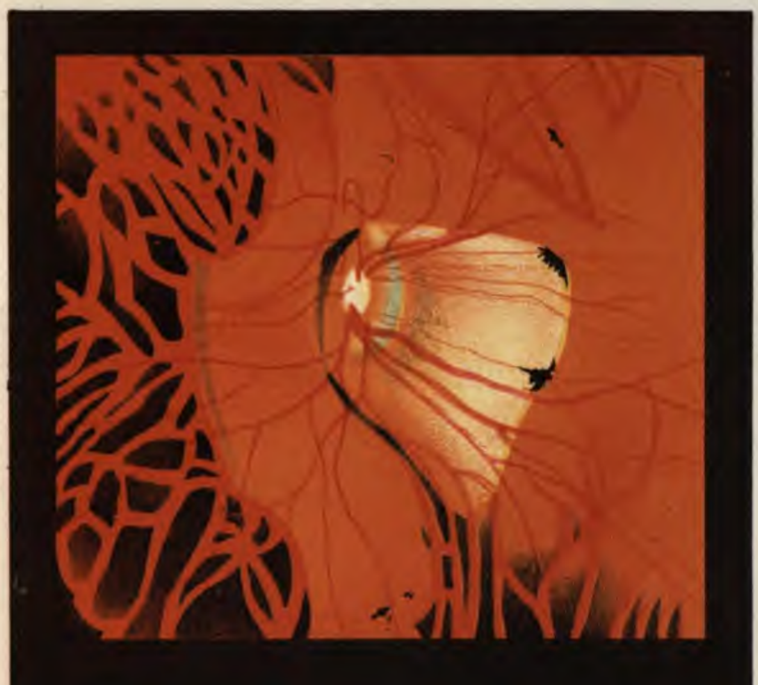

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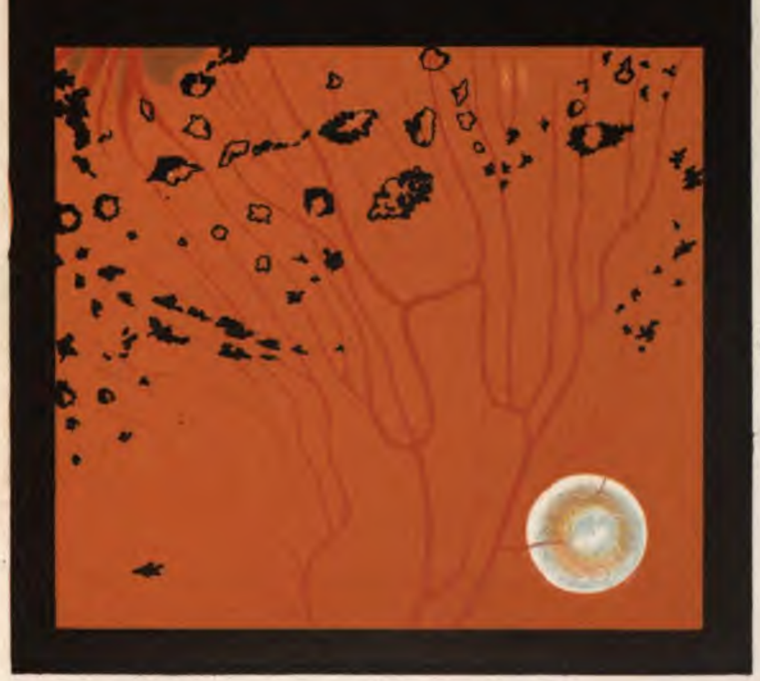

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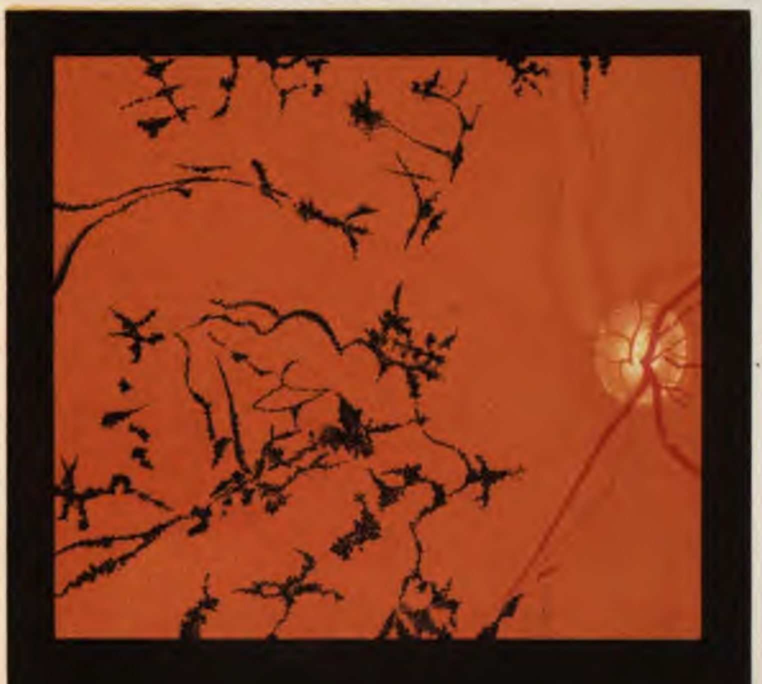

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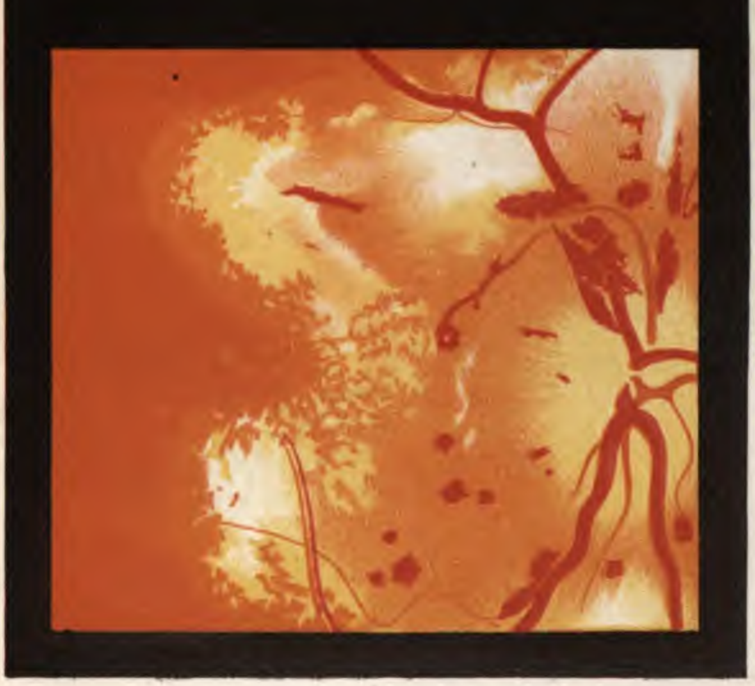

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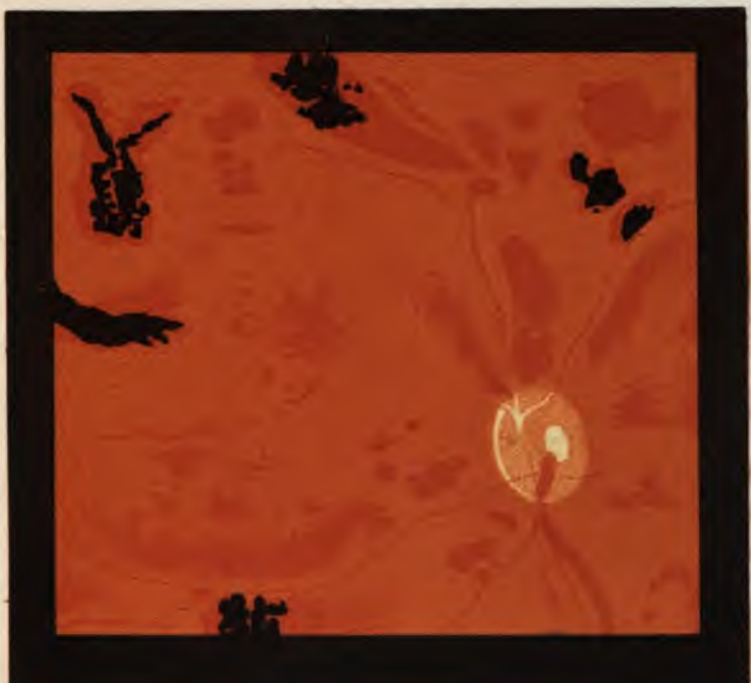

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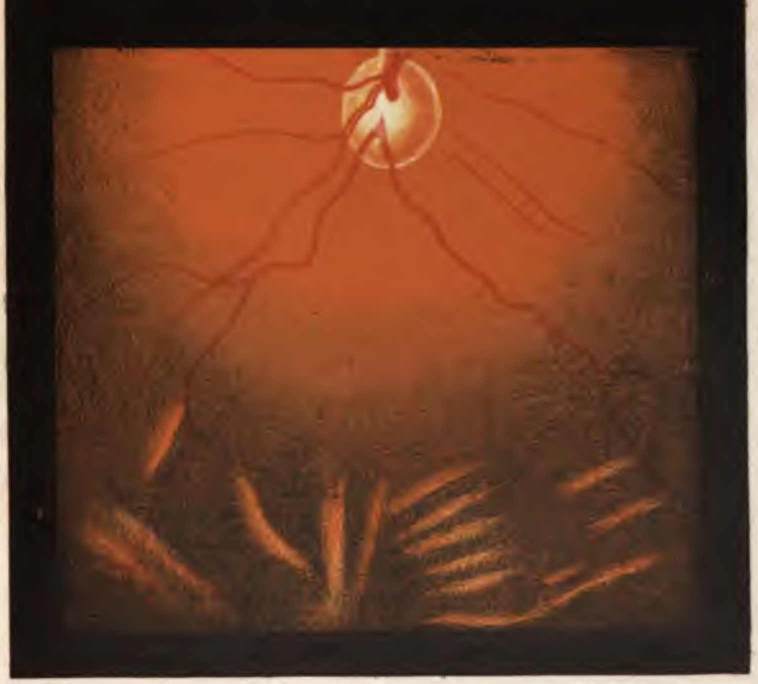

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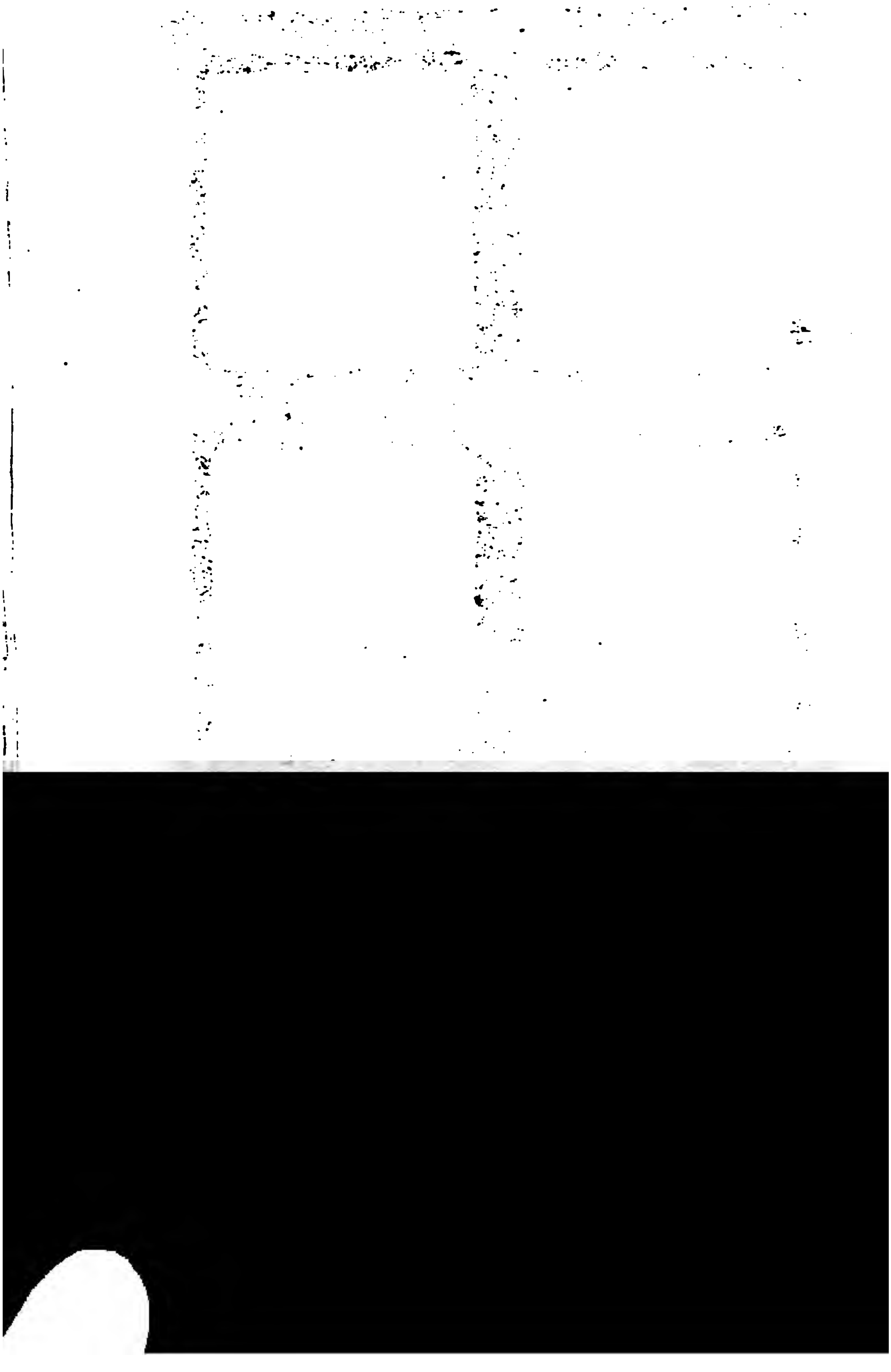

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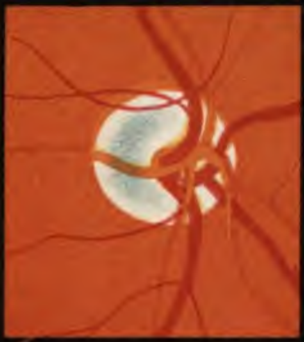

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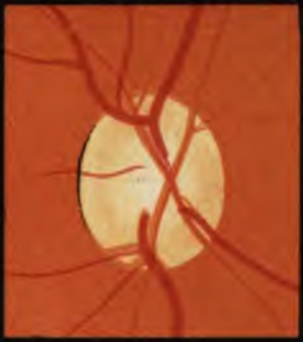

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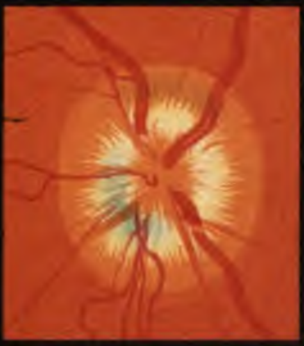

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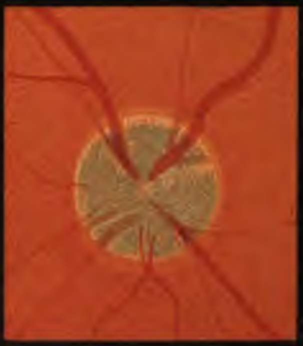

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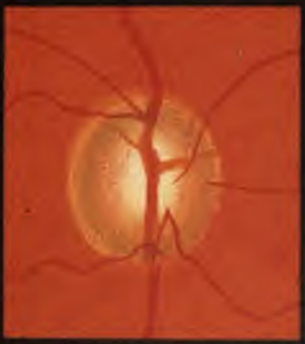

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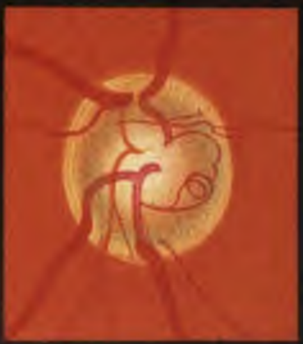

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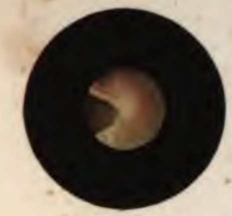

Normal membrana tympani.

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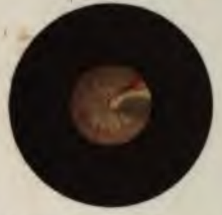

Conjested membrana tympani.

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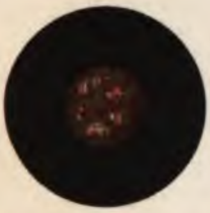

Granulations of membrana tympani.

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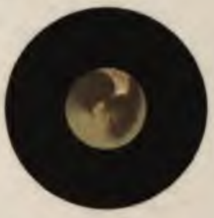

Retracted membrana tympani.

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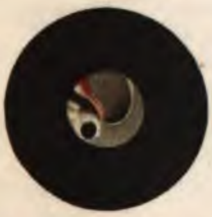

Perforated membrana tympani.

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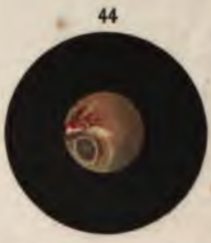

Perforated membrana tympani Inflamed.

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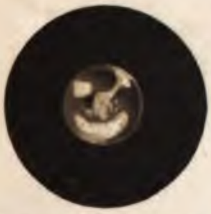

Calcar. deposits on membrana tympani.

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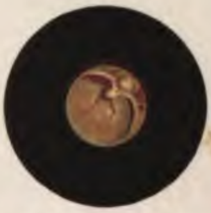

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